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Delivering an Effective, Resilient and Sustainable EU-China Food Safety Partnership



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EU-China-Safe aims at reducing food fraud and improving food safety through focusing on improving food legislation, food inspection and increasing access to information across Europe and China. State-of-the-art technologies including a virtual laboratory will create a unique space to share and demonstrate best practice. The use of innovative technologies will result in improved detection of adulteration of food products as well as increased traceability and transparency of global supply chains.

The project runs from September 2017 to August 2021. It involves 33 partners and is coordinated by QUB (The Queen's University of Belfast, UK).

More information on the project can be found at www.euchinasafe.eu (website in construction)

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Nature of the deliverable		
ORDP	Open Research Data Pilot	
R	Document, report (excluding the periodic and final reports)	R
DEM	Demonstrator, pilot, prototype, plan designs	
DEC	Websites, patents filing, press & media actions, videos, etc.	
E	Ethics	
OTHER	Software, technical diagram, etc.	

Dissemination Level		
PU	Public, fully open, e.g. web	
CO	Confidential, restricted under conditions set out in Model Grant Agreement	CO
CI	Classified, information as referred to in Commission Decision 2001/844/EC	



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1. SUMMARY OF DELIVERABLE 5.3.

Persistent incidents of food fraud have been documented in both the EU and China. Examples of high-profile cases include the 2013 horsemeat scandal in Europe and the 2008 melamine scandal in China. Incidents such as these have had implications for industry credibility, consumer confidence and public health. Current food fraud detection methods typically expose adulterants after suspicion has been raised. However, innovative strategies (blockchain traceability, non-targeted analysis of food for authentication, QR codes for counterfeit protection) present new long-term proactive solutions for ensuring food integrity. They may also help to rebuild consumer confidence and trust in the foods they purchase and consume.

The objective of deliverable 5.3 was to explore whether innovative food fraud strategies can enhance consumer trust in the food chain, as well as add value and increase sales. Two online consumer surveys were conducted. EU infant formula milk (IFM) and processed Chinese garlic were used as exemplar products to understand each export market (Chinese and EU consumers, respectively). Chinese and EU consumer views on innovative food fraud strategies were further explored via focus groups and informed the conclusions of the relevant study (IFM study with Chinese consumers and processed garlic study with EU consumers). Lastly, this deliverable concludes by making some recommendations to industry for improved consumer communication of EU products to China.

2. CHINESE CONSUMER PERCEPTIONS ON THE GEOGRAPHICAL ORIGIN VERIFICATION OF EU INFANT FORMULA MILK: AN ONLINE SURVEY

2.1. ABSTRACT

A system of convincingly highlighting and guaranteeing the origin of EU IFM to consumers could be a worthwhile investment for European exporters. The objectives of this study were first to explore Chinese consumer attitudes and beliefs towards verifying the origin of EU IFM. Second, to explore the relative importance, to the Chinese consumer, of two different origin assurances on EU IFM. Third, to identify determinants of consumers' purchasing intentions toward two identical EU IFMs with different origin assurances.

A well-known global market research company recruited the participants (n=996) and hosted the online data collection during June 2021. The majority of participants were female (68.7%), aged 25-34 years (47.4%), had completed university-level education (77.0%) and were working full-time (94.8%). As they were recruited based on income, they were representative of the identified target market for EU infant formula (middle/high income Chinese consumers). All had purchased IFM in the three months prior to sampling.

Participants were presented with two different ways in which the geographical origin of EU IFM could be verified. The first way was based upon a product recently launched in China for Danone's Aptamil and Nutrilon brands. Essentially, two innovative strategies were described as ways to assure the consumer about origin integrity (blockchain traceability and QR codes for counterfeit protection). We referred to products with these technologies as 'tracked EU infant formula milk'. The second way was based upon a new



technology (non-targeted analysis of IFM) that could be made available to consumers in the future. We referred to products with this technology as ‘tested EU infant formula milk’.

Chinese consumers thought that a system of convincingly guaranteeing the geographic origin of IFM from the EU would be beneficial/important/essential. Specifically, participants thought that an origin guarantee would improve product safety, quality, and trust, while being beneficial to infants. It was also viewed as being ‘good for infant health’. An origin guarantee would also benefit the EU (reputation, economy) and improve trust in both EU manufacturers and Chinese stakeholders (retailers, regulators, and the government). Trust in tracked and tested IMF from the EU (and its manufacturers) was higher than that of domestic IFM (and its manufacturers) but did not differ between the tracked and tested EU IFM. High and similar purchase intentions towards the tracked and tested EU IFM were also reported, however, in a choice question, participants did express a preference for the tracked IFM. When a sub-set (n = 249) of participants were asked about their willingness to pay for both the tracked and tested EU IFM, mean values did not differ (approximately 400CNY per pack/can). Manufacturer trust was the main determinant of intention to purchase both the tracked and tested EU IFM.

These findings show that a system of guaranteeing the origin of EU IFM is well received by Chinese consumers and may be a worthwhile investment for EU IFM exporters.

2.2. INTRODUCTION

Persistent incidents of food fraud have been documented in Chinese domestic food chains. Probably the most notorious incident erupted in 2008, when consumers were shocked to learn that a chemical used in the manufacture of plastics, melamine, was found in domestic IFM. It was estimated to be responsible for at least six infant deaths and a further 300,000 cases of illness. Although consumer confidence in domestically branded formulas initially plummeted and remained low for some years, there is now some recent evidence to suggest that consumer confidence may have improved (Shan et al., 2021). This may, in part, be due to the tightening of regulations or even specific steps taken by the Chinese dairy industry to regain consumer confidence (e.g., sourcing milk powders from overseas). Indeed, in today’s market, it is increasingly difficult for consumers to identify a formula as ‘imported/foreign’ or ‘domestic’ and use this classification as a quality signal. However, a recent study (Shan et al., 2021) has shown that foreign branded, produced, and packaged formulas still show high popularity among consumers in larger and more prosperous higher tier cities. A system of convincingly highlighting and guaranteeing the origin of EU infant formula could therefore be a worthwhile investment for European exporters.

The objectives of this study were first to explore Chinese consumer attitudes and beliefs towards verifying the origin of EU IFM. Second, to explore the relative importance, to the Chinese consumer, of two different origin assurances on EU IFM. Third, to identify determinants of consumers’ purchasing intentions toward two identical EU IMFs with different origin assurances.

For the purposes of this paper, we defined an EU IFM as one which uses EU ingredients and is produced within the EU, whereas a domestic IFM was defined as one which uses domestic ingredients and is produced domestically.

2.3. MATERIALS AND METHODS

2.3.1. Chinese consumer survey data collection and sample description



A well-known global market research firm recruited the participants from two of their existing panels and hosted the online data collection during June 2021. Target sample sizes were 1000 middle/high income Chinese consumers. Given the profiling information available on each panel, the research firm approached the recruitment by directly targeting potential participants based on personal income (CNY 70,000+ in panel one) and household income second (CNY 120,000+ in panel two). To qualify for the survey, participants had to be 18 years old or older and have had purchased IFM in the three months prior to sampling. Participants who worked in or had anyone in their household working in the IFM industry were excluded (due to their existing knowledge and potential bias). ‘Speeders’ (those who had abnormally fast completion times) were removed by the online panel provider. The survey took approximately 20 minutes to complete and was approved (MHLS 21_53) by the Faculty of Medicine, Health and Life Sciences Research Ethics Committee at Queen’s University Belfast Ethical Committee.

2.3.2. Questionnaire design and outline

The master questionnaire was first developed in English by consumer scientists and then translated into Chinese by bilingual researchers employed by the market research firm. The translation was double checked by two native Chinese speakers who were also consumer scientists and members of the research team. The survey began with screening and sociodemographic questions. Next, participants were given a generic definition of food fraud (described in section 2.3.3) and asked questions to specifically determine their risk perception in relation to IFM fraud, and their views regarding the adequacy of its governance. The third section asked participants to rate the quality and safety of a domestic and EU brand of IFM and specifically explored trust in domestic IFM (trust in the actual product and its manufacturers). In section four, participants were presented with two different ways (described in section 2.3.4) in which the geographical origin of EU IFM could be assured. The attitudes and benefits that they attached to demonstrating the origin authenticity of EU formula were then explored. Next, participants completed items relating to their trust and purchasing intentions toward two origin assured EU IFM’s; ‘tracked EU infant formula milk’ (described in section 2.3.4.1) and ‘tested EU infant formula milk’ (described in section 2.3.4.2). We assessed product trust and manufacturer trust for the tracked and tested EU IFM in the same way as for the domestic IFM.

2.3.3. Definition of food fraud

“**Food fraud** is committed when a food is misdescribed with the intention of deceiving the consumer for financial gain. This means that the origin of food, its composition and/or how it was obtained/prepared may not be truthful. There are many types of food fraud, for example:

- counterfeiting – copying the brand name, packaging etc.
- mislabeling – making a false claim on the packaging.
- substitution – replacing part of the product (or an ingredient) with something cheaper.
- unapproved enhancement – adding unknown materials to improve quality.

Often, when people talk about **food fraud**, they may refer to the food as being “**fake**”.



2.3.4. Definition and pictorial example of tracked and tested EU IFM

Participants were presented with two different ways in which the geographical origin of EU IFM could be authenticated. The first way was based upon a product recently launched in China for Danone's Aptamil and Nutrilon brands (Danone, 2020). Essentially, two innovative strategies were described as ways to assure the consumer about origin integrity (blockchain traceability and QR codes for counterfeit protection). We referred to products with these technologies as 'tracked EU infant formula milk'. The second way was based upon a new technology (non-targeted analysis of IFM) that could be made available to consumers in the future. We referred to products with this technology as 'tested EU infant formula milk'. Participants read the below paragraphs in relation to the tracked and tested EU IFM products.

2.3.4.1. Tracked EU IFM

The **pack** is given "a **tracked** geographical identity using **high-end record-keeping technology**. For this to work, a unique QR code is laser printed on the outer pack of the infant formula milk, and a second QR code is laser printed behind a tamper-resistant seal on the inside. The outer QR code is used by the manufacturer for tracking the pack through the supply chain, and by the consumers to see **where the formula was manufactured and the product's journey through the supply chain**. After purchasing and opening the tamper-resistant pack, consumers can scan the inner QR code which triggers a one-time message verifying that **the pack is a genuine product**. The product is verified as genuine if the unique inner QR code exists in the manufacturer's database and hasn't been scanned before. Both QR codes can be scanned via a dedicated app, WeChat, or a standard QR code scanner. Please view the image below."



Figure 1. Tracked EU infant formula milk. This picture has been adapted from a picture taken from <https://packagingeurope.com/danone-introduces-track-and-connect/>

2.3.4.2. Tested EU IFM



The **formula** (in the pack) is given “a **tested** geographical identity using **high-end analytical scanning technology**. Here, the formula is tested using an analytical scanning device at EU manufacturing sites and given a unique fingerprint which is specific to its geographic origin. After opening the tamper-resistant pack, consumers can use a special food scanning device (connected to a dedicated mobile app) to scan an area of the formula itself. The scanning device then communicates this captured sensory data and contextual information via wireless mobile networking to a cloud platform for further analysis. The cloud platform can then immediately **reveal the geographic origin of the formula** to the consumer (at their mobile application/screen). Please view the image below.”

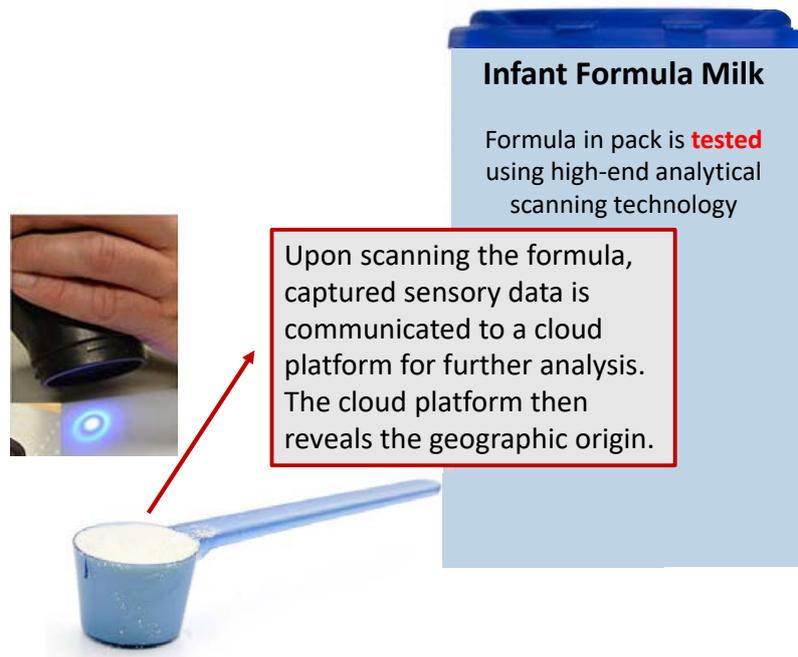


Figure 2. Tested EU infant formula milk. This picture has been adapted from the tested infant formula; it also includes two photographic images taken from the web.

2.3.5. Questionnaire items

Risk perception in relation to IFM fraud: Participants rated their feelings with six statements about their risk perception of IFM fraud on 7-point semantic differential scales (See Table 2). These Items were based on five risk characteristics used in the Perceived Food Risk Index questionnaire (PFRI) (Fife, Schaw & Rowe, 1996): likelihood of health risk (LIKELY), severity of health risk (SEVERITY), worry about potential risks (WORRY), personal ability to detect risk (EASYTELL), personal ability to control risk (CONTROL), and the perceived adequacy of IFM regulations and their enforcement (BADREGS).

Quality and safety of domestic and EU IFM: Participants were asked to rate the quality and safety of a “well-known domestic brand” of IFM (domestic main ingredients, produced domestically) and a “well-known EU brand” of IFM (EU main ingredients, produced in the EU). The seven nominal response categories ranged from “extremely low product quality and safety” (1) to “extremely high product quality and safety” (7).

Trust in domestic IFM: To measure trust in domestic IFM, participants responded to five statements on a 7-point Likert-type scale (1 = “strongly disagree”, 7 = “strongly agree”). They indicated the extent to which



they trusted that domestic IFM: “is good quality”, “is accurately labelled”, “is safe”, “has passed the required controls”, and “has not been tampered with in any way and is what it says it is”.

Trust in domestic IFM manufacturers: To measure trust in manufacturers of domestic IFM, participants responded to five statements on a 7-point Likert-type scale (1 = “strongly disagree”, 7 = “strongly agree”). They indicated the extent to which manufacturers of domestic IFM: “take good care of the quality of their products”, “give special attention to the quality of their products”, “are honest about the quality of their products”, “are sufficiently open regarding the quality of their products”, and “can be trusted to protect the consumer from low quality products”. Participants were asked to consider the word ‘quality’ as a concept which also includes safety. This 5-item scale was inspired by five items (and their factor loadings) in the 7-item food chain trust scale developed by Benson et al. (2020).

Attitude towards verifying the origin of EU IFM: Cognitive attitude was assessed by three items (i.e., “A system of convincingly guaranteeing the geographic origin of infant formula milk from the EU would be”: “beneficial”, “important”, “essential”). Items were scored on a 7-point Likert scale (1 = “strongly disagree”, 7 = “strongly agree”).

Belief towards verifying the origin of EU IFM: To measure benefits that could be attached to EU IFM with a verified origin, participants responded to 11 statements (e.g. “Guaranteeing the geographic origin of infant formula milk from the EU would”: “be good for infant health”, “improve the safety of this product”, “improve the quality of this product”, “be beneficial to infants”, “be beneficial to the EU economy”, “improve the reputation of the EU”, “improve trust in this product”, “improve trust in the manufacturers of this product”, “improve trust in Chinese retailers who sell this product”, “improve trust in Chinese regulators”, “improve trust in the Chinese government”). Items were scored on a 7-point Likert scale (1 = “strongly disagree”, 7 = “strongly agree”).

Trust in tracked and tested EU IFM (and their manufacturers): Trust in tracked and tested EU IFM (and their manufacturers) was measured in the same way as for the domestic product (described above).

Intention to purchase a tracked/tested EU IFM: Intention to purchase tracked and tested EU IFM was assessed by three items per product (i.e., “If I was buying EU infant formula milk,”: “I would plan to buy products with a tracked/tested geographical identity”, “I would want to buy products with a tracked/tested geographical identity”, “I would intend to buy products with a tracked/tested geographical identity”). Items were scored on a 7-point Likert scale (1 = “strongly disagree”, 7 = “strongly agree”).

Willingness to pay for a tracked/tested EU IFM: Willingness to pay for a tracked and tested EU IFM was assessed by one item per product (i.e., “What is the highest price that you would you be willing to pay for an infant formula milk from the EU with a tracked/tested geographical identity?”). Responses were given to the nearest whole Yuan for a pack/can. Only n=249 participants completed these items.

Product preference (tracked or tested EU IFM): Participants were asked two questions: “If the below EU products were the same price, which product would you prefer to buy?” and “If the below EU products were the same price, but you had to pay for the scanning device in picture two, which product would you prefer to buy?”. They viewed two product pictures (tracked and tested IFM) side by side and made their selection.

2.3.6. Data analysis

All analyses were conducted using IBM SPSS Statistics for Windows version 26.0 (IBM Corporation, Armonk, NY, USA).



Descriptive and factor analysis: First, the demographic details and characteristics of the study sample were summarised with percentage frequencies. A maximum likelihood factor analysis with Direct Oblimin rotation was then conducted to identify a measurement model for the seven risk perceptions. A three-factor solution was obtained. Cronbach's α and Pearson correlations coefficients were used to assess the internal reliability of all study scales, depending on whether there were two or more items in each scale. Scales were constructed by computing a mean of all items (scales ranged from a minimum of 1 to a maximum of 7) and descriptive statistics (means and SD) were calculated for all scales and their items. A one-way repeated measures ANOVA with a post-hoc Bonferroni test was applied to compare participants trust in different IFM. Paired t-tests were used to determine if there were differences in purchasing intentions between tracked and tested EU IFM.

Regression analysis: Finally, a hierarchical multiple regression examined the association between demographics (age, gender, personal income, education) and intention to purchase each EU IFM (tracked and tested). Then, we tested an extended version of the demographic model including the three risk perception constructs and manufacturer trust.

2.4. RESULTS

2.4.1. Demographic summary

Demographic details and characteristics of the N=996 participants (n=613 from panel one and n=383 from panel two) are detailed in Table 1. The majority of participants were female (68.7%), aged 25-34 years (47.4%), had completed university-level education (77.0%) and were working full-time (94.8%). As they were recruited based on income, they were representative of the identified target market for EU infant formula (middle/high income Chinese consumers). Participants (64.3%) mainly used a Chinese brand (vs foreign brand) of IFM, and most (72.8%) stated that China was the manufacturing origin. A minority of participants were unsure about the formulas brand (8.9%) and country of manufacture (7.5%).

Table 1

Demographic details and characteristics of the survey participants (N=996).

	N=996
	%
Gender	
Male	31.0
Female	68.7
Other	0.3
Age (years)	
18-24	10.5
25-34	47.4
35-44	12.1
45-54	18.3
55+	11.6
Residential place	
Tier 1 cities (i.e., Beijing, Shanghai, Guangzhou, and Shenzhen)	38.6
Tier 2 cities (e.g., Chengdu, Hangzhou, Nanjing, Changsha)	33.5



Tier 3 cities (e.g., Linyi, Ningbo, Suzhou, Zhengzhou)	27.9
Education	
Secondary school and below	4.2
College, senior occupational/technical school	18.8
University bachelor's degree	71.8
Master's degree or higher	5.2
Occupation status	
Working full-time	94.8
Working part-time	3.7
Retired	0.8
Other	0.7
Household gross monthly income	
Less than CNY 10000	2.1
CNY 10000-14999	24.4
CNY 15000-19999	38.3
CNY 20000 and higher	35.2
Personal income	
Less than CNY 70000	5.6
CNY 70001-80000	19.5
CNY 80001-90000	13.1
CNY 90001-100000	10.1
CNY 100001-150000	25.3
CNY 150001-200000	13.8
CNY 200001-500000	10.5
CNY 500001 and higher	2.1
Person(s) for whom they purchase formula for (select all that apply)	
My child(ren)	74.7
My grandchild(ren)	25.7
Main brand of formula purchased	
Chinese brand	64.3
Foreign brand	26.8
Unsure	8.9
Is the above brand manufactured in China?	
Yes	72.8
No	19.7
Unsure	7.5

2.4.2. Descriptive summary

2.4.2.1. Risk perceptions in relation to IFM fraud

Table 2 details the means (SD) of the three risk perception constructs.

Table 2

Mean (SD) of risk perceptions in relation to infant formula milk fraud. Items were scored on a 7-point Likert-type scale (endpoints included in parenthesis) and factor analysed into three scales.



	N=996
	Mean (SD)
Likelihood and severity of infant formula milk fraud (3 items)¹	5.40 (1.38)
How likely is it that their health will ever be harmed by fake infant formula milk? Scale: not likely at all (1) – extremely likely (7)	5.43 (1.58)
How seriously do you think fake infant formula milk may harm their health? Scale: not seriously at all (1) – extremely seriously (7)	5.51 (1.58)
How worried are you about potential risks associated with fake infant formula milk Scale: not worried at all (1) – extremely worried (7)	5.26 (1.54)
Susceptibility to infant formula milk fraud (2 items)²	4.51 (1.35)
How easy is it for you to tell if infant formula milk is fake? Scale: you can never tell (1) – you can always tell (7)	4.41 (1.58)
To what extent can you control whether you purchase fake infant formula milk? Scale: no control (1) to total control (7)	4.62 (1.42)
Adequacy of governance in relation to infant formula milk (2 items)³	5.08 (1.21)
Current regulations in China are adequate to protect infants from the potential risks of fake infant formula milk Scale: strongly disagree (1) – strongly agree (7)	5.06 (1.29)
Current enforcement of regulations in China are adequate to protect infants from the potential risks of fake infant formula milk Scale: strongly disagree (1) – strongly agree (7)	5.10 (1.35)

¹Internal consistency of scale is 0.85.

²Internal consistency of scale is 0.62.

³Internal consistency of scale is 0.69.

2.4.2.2. Quality and safety of domestic and EU brands of IFM

Participants rated the quality and safety of domestic and EU IFM to be ‘somewhat high’. They perceived that the quality and safety of an EU IFM was significantly ($p < 0.001$) higher than that of domestic IFM: 5.36 (1.2) vs 5.03 (1.23), respectively.

2.4.2.3. Attitude and belief towards verifying the origin of EU IFM

Participants reported a general favourable attitude with positive beliefs towards EU IFM with a guaranteed geographic origin (Table 3). Participants viewed that a system of convincingly guaranteeing the geographic origin of IFM from the EU would be beneficial/important/essential. Specifically, participants thought that an origin guarantee would improve product safety, quality, and trust, while being beneficial to infants (all items scored above 5.7). It was also viewed as being ‘good for infant health’: 5.66 (1.10). An origin guarantee would also benefit the EU (reputation, economy) and improve trust in both EU manufacturers and Chinese stakeholders (retailers, regulators, and the government).

Table 3

Mean (SD) of attitudinal dimensions and beliefs of verifying the origin of EU infant formula milk. Items were scored on a 7-point Likert-type scale (1 = “strongly disagree”, 7 = “strongly agree”).

	N=996
	Mean (SD)
Attitude towards verifying the origin of EU infant formula milk (three items)¹	5.73 (0.89)



A system of convincingly guaranteeing the geographic origin of infant formula milk from the EU would be:

beneficial	5.69 (1.09)
important	5.75 (1.06)
essential	5.73 (1.04)

Beliefs toward verifying the origin of EU infant formula milk (11 items)² **5.69 (0.82)**

Guaranteeing the geographic origin of infant formula milk from the EU would:

be good for infant health	5.66 (1.10)
improve the safety of this product	5.78 (1.10)
improve the quality of this product	5.75 (1.01)
be beneficial to infants	5.74 (1.02)
be beneficial to the EU economy	5.65 (1.05)
improve the reputation of the EU	5.65 (1.12)
improve trust in this product	5.70 (1.15)
improve trust in the manufacturers of this product	5.70 (1.11)
improve trust in Chinese retailers who sell this product	5.65 (1.10)
improve trust in Chinese regulators	5.66 (1.07)
improve trust in the Chinese government	5.66 (1.10)

¹Internal consistency of scale is 0.79

²Internal consistency of scale is 0.93

2.4.2.4. Product trust (domestic IFM and tracked and tested EU IFM)

Table 4 shows that there was a statistically significant difference between IFM product trust as determined by one-way repeated measures ANOVA ($F(115.35,723.99) = 158.55, p < 0.001$). A Bonferroni post-hoc test revealed that trust in domestic IFM (5.24) was statistically ($p < 0.001$) lower than trust in the tracked and tested EU IFM (5.64 and 5.66, respectively). There was no statistically significant difference between the tracked and tested EU IFM ($p = 0.63$).

Table 4

Mean (SD) trust in domestic infant formula and tracked and tested EU infant formula milk. Items were scored on a 7-point Likert-type scale (1 = “strongly disagree”, 7 = “strongly agree”).

	Domestic infant formula milk	Tracked EU Infant formula milk	Tested EU Infant formula milk
Product trust¹	5.24 (1.00)^a	5.64 (0.86)^b	5.66 (0.88)^b
is good quality	5.17 (1.2)	5.49 (1.30)	5.55 (1.10)
is safe	5.29 (1.18)	5.71 (1.04)	5.72 (1.05)
is accurately labelled	5.24 (1.17)	5.68 (1.13)	5.71 (1.07)
has passed the required controls	5.33 (1.16)	5.68 (1.02)	5.67 (1.07)
has not been tampered with in any way and is what it says it is	5.16 (1.17)	5.66 (1.03)	5.66 (1.09)

¹Internal consistency of scale is 0.90, 0.83, and 0.88 for domestic, tracked, and tested formulas, respectively.

Different superscripts^(a-b) indicate significantly different ($p < 0.001$) product trust between infant milk formulas with one-way repeated measures ANOVA and Bonferroni post-hoc test.



2.4.2.5. Manufacturer trust (domestic IFM and tracked and tested EU IFM)

Table 5 shows that there was a statistically significant difference between IFM manufacturer trust as determined by one-way repeated measures ANOVA ($F(115.67,735.47) = 156.49, p < 0.001$). A Bonferroni post-hoc test revealed that trust in domestic IFM manufacturers (5.25) was statistically ($p < 0.001$) lower than trust in tracked and tested EU IFM manufacturers (5.67 and 5.66, respectively). There was no statistically significant difference in manufacturer trust between the tracked and tested EU IFM ($p = 1.00$).

Table 5

Mean (SD) trust in manufacturers of domestic infant formula and manufacturers of tracked and tested EU infant formula milk. Items were scored on a 7-point Likert-type scale (1 = “strongly disagree”, 7 = “strongly agree”).

	Domestic infant formula milk	Tracked EU Infant formula milk	Tested EU Infant formula milk
Manufacturer trust¹	5.25 (1.05)^a	5.67 (0.85)^b	5.66 (0.84)^b
take good care of the quality of their products	5.20 (1.21)	5.61 (1.11)	5.63 (1.14)
give special attention to the quality of their products	5.34 (1.21)	5.72 (1.09)	5.70 (1.06)
are honest about the quality of their products	5.24 (1.23)	5.65 (1.04)	5.68 (1.03)
are sufficiently open regarding the quality of their products	5.23 (1.24)	5.69 (1.05)	5.66 (1.06)
can be trusted to protect the consumer from low quality products	5.23 (1.24)	5.67 (1.05)	5.66 (1.07)

¹Internal consistency of scale is 0.91, 0.86, and 0.85 for domestic, tracked, and tested formulas, respectively.

Different superscripts^(a-b) indicate significantly different ($p < 0.001$) manufacturer trust between infant milk formulas with one-way repeated measures ANOVA and Bonferroni post-hoc test.

2.4.2.6. Intention to purchase a tracked/tested EU IFM

Purchasing intentions toward the tracked and tested EU IFM were high (5.74 (0.93) vs 5.72 (0.92), respectively) and similar ($p = 0.32$).

Table 6

Mean (SD) intention to purchase tracked and tested EU infant formula milk. Items were scored on a 7-point Likert-type scale (1 = “strongly disagree”, 7 = “strongly agree”).

	Tracked EU Infant formula milk	Tested EU Infant formula milk
Intention to purchase¹	5.74 (0.93)	5.72 (0.92)^a
If I was buying EU infant formula milk, I would:		
plan to buy products with a tracked/tested geographical identity	5.66 (1.11)	5.64 (1.13)



want to buy products with a tracked/tested geographical identity	5.79 (1.07)	5.76 (1.10)
intend to buy products with a tracked/tested geographical identity	5.69 (1.09)	5.76 (1.05)

¹Internal consistency of both scales is 0.81.

^(a)not significantly ($p = 0.32$) different from tracked EU infant formula milk with paired t-test.

2.4.2.7. Willingness to pay for a tracked/tested EU IFM

The highest price that participants ($n=249$) would be willing to pay for the tracked EU IFM was the same as the tested IFM (391 (317) CNY vs. 404 (321) CNY, respectively; $p = 0.14$).

2.4.2.8. Product preference (tracked or tested EU IFM)

The majority of participants (61.4%) stated a preference for purchasing the tracked EU IFM, while 38.6% of participants stated a preference for purchasing the tested EU IFM. The figure of 38.6% for the tested product rose to 43.7% when participants were told that they had to pay for the scanning device required for the tested EU IFM.

2.4.3. Determinants of purchasing intentions toward tracked/tested EU IFM

The demographic model explained (based on R^2_{adj}) 2.0% of the variance in intention to purchase the tracked product and 2.9% of the variance in intention to purchase the tested product (Table 6). Education was the main demographic determinant of intention to purchase each product; with high education (i.e., university) associated with a lower purchasing intention.

The explained variance (based on R^2_{adj}) in intention to purchase EU IFM increased significantly to 70.2% for the tracked product ($p < 0.001$) and 75.4% for the tested product ($p < 0.001$) when the demographic-model was extended with risk perceptions and manufacturer trust. While demographics (gender, education, personal income) were no longer significant drivers of intention to purchase each EU IFM, manufacturer trust became a significant main determinant ($\beta=0.821$ and $\beta=0.844$ for the tracked and tested IMFs respectively), followed by perceptions related to the likelihood and severity of IFM fraud. Susceptibility to IFM fraud and the adequacy of governance in relation to IFM did not emerge as significant predictors.

Table 6

Standardized regression coefficients (β) for the demographic model and the demographic-extended model predicting intention to purchase a tracked/tested EU IFM.

Independent constructs	Demographic model		Demographic-extended model	
	Tracked EU infant formula milk ¹	Tested EU infant formula milk ¹	Tracked EU infant formula milk ¹	Tested EU infant formula milk ¹
Age (years)	0.001	-0.004	-0.002	-0.007
Gender ²	0.065*	0.088**	-0.027	0.007
Education ³	-0.124***	-0.156***	0.003	-0.028
Personal income ⁴	0.100**	0.092**	0.005	0.009
Likelihood and severity of infant formula milk fraud ¹			0.076***	0.045*
			-0.015	-0.022



Susceptibility to infant formula milk fraud ¹				-0.001	0.028
Adequacy of governance in relation to infant formula milk ¹				0.821***	0.844***
Manufacturer trust ¹					
R^2_{adj}	0.020	0.029		0.702	0.754
Model F	5.941***	8.438***		292.550***	381.848***
df	4,988	4,988		8,984	8,984

* $p \leq 0.05$; ** $p < 0.01$, *** $p < 0.001$; bold text highlights significance.

¹ Mean of variable items on a 7-point Likert scale; higher scores indicative of stronger (i.e., more positive) levels of the construct.

² 0 = male, 1 = female.

³ 0 = no university education, 1 = university education.

⁴ 14 categories of increasing salary.

2.5. CONCLUSIONS

The current survey study had three objectives. First, to explore Chinese consumer attitudes and beliefs towards verifying the origin of EU IFM. Second, to explore the relative importance, to the Chinese consumer, of two different origin assurances on EU IFM. Third, to identify determinants of consumers' purchasing intentions toward two identical EU IFMs with different origin assurances.

2.5.1. Consumer attitudes and beliefs towards verifying the origin of EU IFM

Overall, we found that Chinese participants judge origin to be an important attribute of IFM. The most positive belief connected with origin assured EU IFM is the belief that it will improve the safety of the product, followed closely by the belief that it will improve the quality of the product. Participants also believed that a system of guaranteeing the origin of EU IFM would improve trust (in the product and its manufacturers, Chinese retailers, Chinese regulators, and the Chinese government) and be beneficial for infants.

Country of origin was also found to be an important IFM attribute for Chinese focus group (FG) participants. Specifically, FG participants acknowledged that foods of EU origin were generally more trustworthy and safer in comparison to foods originating from Asian or less developed countries. Reasons for this centred around country distinctions in "economic capacity", "technological level", "political factors", "human rights", "food law" (rules, standards and certifications for food quality and safety, including food traceability) and the enforcement of legislation; of which the EU was deemed to be superior in each regard. Overall, FG participants praised EU food authorities for being open and transparent, and this subsequently gained their trust in the EU food industry and its products. Among participants, there was a belief that all nonconformity in the EU food industry would publicly be made known. FG participants acknowledged that positive personal experiences and limited "negative news" (from the press or friends) also further substantiated their high trust in the EU food system. The following FG quotes emphasise these points:

Quote one: *"I have different levels of trust in products sold in different countries. For food under the EU system, I personally have more trust. I believe that European products are the most demanding,*



and then probably countries like the UK and the US, and then Asian countries like Japan and South Korea. For Chinese food, because we have seen reports of food safety incidents in the news, the trust is not very high”.

Quote two: “I trust that food sold in developed countries is safe, because of economic capacity and technological level, and political factors are also considered. I think that food in countries that pay more attention to human rights will be safer”.

Quote three: “According to the news I have seen, I feel that the Irish government attaches more importance to human rights and human health, and puts food safety in the first place, and the industry standards it has formulated are relatively the highest. I didn't hear many negative food news”.

Quote four: “The food laws and regulations here [Ireland] are relatively complete, and they pay great attention to food safety, health and nutrition. If there is a problem, there will be protests and media coverage”.

FG participants viewed that an origin guarantee on food originating from the EU would be most appropriate for foods with a high monetary value. EU infant formula milk was included within this category. For this specific EU product, an origin guarantee would be well received and elicit increased trust in the product as well as a price premium.

Quote four: *I wish there was such a code [origin guarantee], for example, code in Irish infant formula. And I'm willing to pay more for it”.*

Quote five: *“This technology [origin guarantee] is useful for infant formula. Some infant formula products claim they are origin from Netherlands or Ireland, but you can't validate it is true or not. If this technology can show the real country of origin and dispatch place, then I will pay more to get a reliable product”.*

2.5.2. Relative importance of two different origin assurances on EU IFM

In the literature, there has been little consideration given as to how food fraud technologies impact on consumer trust in products and influence intention to purchase. In this survey study we explored the relative importance of two different origin assurances of EU IFM. Our results showed that both types of origin assurance were equally well received by Chinese consumers. Specifically, we found that trusts (product and manufacturer) toward the tracked and tested products were high and similar. Indeed, trust in both products (and their manufacturers) compared favourably to that of domestic IFM, and purchase intentions for the tracked and tested formulas were similarly high. The price that participants (n=249) were willing to pay was comparable to high-end (i.e., organic/traceable) imported infant formula from Europe. The only difference between the tracked and tested EU IFM was revealed through a product preference question, wherein most participants (61%) stated a preference for the tracked formula.

Given previous research which demonstrates Chinese distrust of QR codes, we are unsure why the tracked and tested IFMs (the latter without a QR code) were almost equally well received. It could be reasonable to postulate that a participant's possible prior familiarity and knowledge of “high-end record keeping technology” (especially the application of blockchain-based traceability to IFM sold in China), might have substantiated the robustness of the tracking technology. Indeed, familiarity with the robustness of this technology (vs “high-end analytical scanning technology”), either on IMF labels or through industry wide promotion/adoption, could be driving the product preferences towards the tracked product. Interestingly,



preference for the tested EU IFM increased when participants were told that they had to pay for the formula scanning device. This perhaps indicates that the origin verification is more independently governed and trustworthy.

Within the focus groups, all technologies (QR codes for counterfeit protection, high-end record-keeping technology, and high-end laboratory techniques) were welcomed, however, counterfeit protection alone was regarded by some to be limited in scope and doubts were expressed by a few participants regarding the trustworthiness of “high-end record keeping technology” and the QR codes which would be scanned to access this information. High-end laboratory testing was viewed as being independent of the brand, desirable, and trustworthy if overseen by a “large authoritative testing organisation”. It was perhaps the preferred testing method, however, there was still a desire for consumers to be connected to actors within the chain and tap into the benefits that were presented to consumers through the tracked survey product.

Quote six: *“I can verify this product is a genuine product, but it cannot guarantee that the manufacturer is doing everything right in the process. This code [QR code for counterfeit protection] can help us know this is a genuine product but won’t increase my trust in food. The most food we purchase are not of high value. So, this technology seems unnecessary. Supervision and quality control will help increase consumers’ trust in food”.*

Quote seven: *“This technology [high-end tracking technology] is just a courier history, like a luxury bag bought overseas and shipped to China, the history of a product can be faked. This technology does not increase my trust in the product”.*

Quote seven: *“The third technology [high-end laboratory techniques] is better than the previous two [QR codes for counterfeit protection, high-end record-keeping traceability]. They [previous two] are based on my trust in the brands. It will not increase my trust in food. If it is a relatively large authoritative testing organization, it can increase my trust in food. Especially for the counterfeiting of meat and alcohol. Regarding whether I will pay more for it, it depends on the value of food, e.g., high-value and easily counterfeit food”.*

Altogether, these results highlight that the Chinese consumers question the robustness of technologies in the fight against food fraud. Communication in this area is key, and the role of an independent body to oversee such a system should not be underestimated. It would be interesting to see if high-end laboratory testing coupled with an insight into the manufacturer could outperform the tracked IFM i.e., is the tracked product valued because it is tracked from its origin, or, because it connects the consumer to its manufacturer and creates accountability (see below).

2.5.3. Manufacturer trust as a key determinant of intention to purchase a tracked/tested EU IFM

Manufacturer trust explained a large proportion of the variance in intention to purchase a tracked/tested EU IFM. In our scale, openness and care for public well-being constituted trust towards manufacturers. FG participants also welcomed openness and transparency in the supply chain (especially at the manufacturing stage) and viewed it as an effective way to increase their trust. Information on product history created accountability in the food system with the identification of key actors and was viewed positively.

Quote 8: *“One is an example about the “Ye Shu 椰树” brand coconut juice [Chinese brand]. The phone number of their CEO is printed on their package, and it is a real number. Someone has tried to ring, and the CEO answered the phone call. This has helped “Ye Shu” gain a very good reputation among consumers. The*



CEO told the media that he would like to be the first person to hear consumers' feedback or comments about their products. This will definitely increase consumers' trust in food. Another example is about my own experience in Ireland. Some food products are harvested from farms or processed by family business, and they will print the name of the responsible person in their packages, especially hand made products, e.g., crisps. If this technology will provide the responsible person for each process in supply chain, I think it will increase consumers' trust in food".

Quote 9: "I have the opportunity to visit the factory and know that all the information is true, then it will increase my trust in food".

Altogether, these findings show that a system of guaranteeing the origin of EU IFM is well received by Chinese consumers and may be a worthwhile investment for EU IFM exporters.

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3. EU CONSUMER PERCEPTIONS TOWARDS TRACEBLE AND AUTHENTIC GARLIC: AN ONLINE SURVEY

3.1. ABSTRACT

Processed garlic is a valuable spice which is threatened by economic adulteration. In recent years, technological advances have offered new opportunities for block-chain based traceability, while laboratory advances have also offered new non-targeted methods (e.g., chemometrics and spectroscopy) for the authentication of spices through the identification of fraud. However, little research has investigated how consumers might respond to such food fraud technologies. The objectives of this study were first to explore consumer preferences for traceability and authenticity information in relation to processed Chinese garlic. Second, to explore consumer attitudes, beliefs and purchasing intentions towards traceable Chinese processed garlic with an authenticity assurance. Third, to investigate if traceability information and an authenticity assurance can improve consumer trust in Chinese processed garlic and its manufacturers/farmers.

A well-known global market research company recruited participants from Germany and the UK (n = 570) and hosted the online survey data collection during April 2021. Most participants were aged 55-64 years (40.2%), had completed secondary/further education (50.9%), were working full-time (57.0%), and



purchased garlic powder as their most popular processed garlic product (61.8%). All had purchased processed garlic for themselves/their household 3-4 times per year.

Participants initially completed sociodemographic and purchasing items, and items relating to their baseline trust in the processed Chinese garlic chain (farmers and manufacturers) and the product itself. They were then informed about a new product (traceable Chinese garlic) which was traceable from the 'region of origin' to the 'supermarket shelf' and had been tested and verified as garlic. Following this, and specific to traceable processed Chinese garlic with an authenticity assurance, they completed items relating to trust in the product chain (farmers and manufacturers) and the product itself. Attitudes, beliefs, and purchase intentions (including willingness to pay) towards traceable Chinese garlic with an authenticity assurance (vs standard Chinese garlic) were also captured.

When participants were presented with a list of attributes that could be labelled on processed garlic, the vast majority (90%) agreed that they would like to know "that it is actually garlic" they are purchasing. The provision of traceability information with an authenticity assurance increased trust in the product and chain actors (farmers and manufacturers). Participants viewed that buying traceable and authentic processed Chinese garlic would be wise/beneficial and make them feel good/pleased. They also reported more positive perceptions of the product over non-authentic and untraceable garlic (more accurately labelled, safer, of better quality, healthier, etc.). Consumers were willing to pay a premium for authentic and traceable garlic; typically, up to 10% extra but sometimes higher. At the same time, UK participants did differ from German participants in a few ways. Specifically, the provision of traceability information with an authenticity assurance increased product trust more in the UK sample. Participants from the UK (vs Germany) also expressed a significantly more favourable mean score in their attitudes and beliefs towards traceable Chinese garlic.

Assuring the traceability and authenticity of food does come at an additional cost, however, these costs must be weighed against all potential benefits. EU Consumer responses to traceable processed garlic with an authenticity assurance are positive and technologies such as these may be a worthwhile investment for spice manufacturers selling within the EU market, especially those who source outside of the EU.

3.2. INTRODUCTION

China is the top producer of fresh garlic, with a 77.6% share in production (Tridge, 2020). With over 200 varieties, Garlic is one of the world's most popular bulbs used for flavor, and in its dried form, the bulb is used as a spice. Spices are particularly susceptible to food fraud. Adulteration of garlic is most likely to occur in the powdered form. In this form, there is potential for the spice to be adulterated with any white powder – talc and chalk powder are possibilities, as well as corn starch and peanut butter powder.

In recent years, technological advances have offered new opportunities for block-chain based traceability, while laboratory advances have also offered new non-targeted methods (e.g., chemometrics and spectroscopy) for the authentication of spices through the identification of fraud. Traceability is the ability to track a product's journey through the food chain (Bosona & Gebresenbet, 2013), while authenticity refers to the fact that product is genuine and as advertised (Haynes et al., 2019). Assuring the traceability and authenticity of food does come at an additional cost, however, these costs must be weighed against potential benefits. One benefit of traceability information and an authenticity assurance relates to positive consumer responses. Traceability information has been previously communicated to consumers via a Quick Response (QR) code positioned on a product label. QR codes delivering traceability have been found to



increase consumer trust, and positively influence purchase intentions (including willingness to pay) (Spence et al., 2018; Van Rijswijk & Frewer, 2012).

The objectives of this study were first to explore consumer preferences for traceability and authenticity information in relation to processed Chinese garlic. Second, to explore consumer attitudes, beliefs and purchasing intentions towards traceable Chinese processed garlic with an authenticity assurance. Third, to investigate if traceability information and an authenticity assurance can improve consumer trust in Chinese processed garlic and its manufacturers/farmers.

We chose to explore consumer perceptions in two markets (Germany and the UK). Although there appears to have been an increase in domestic garlic consumption in both Germany and the UK in recent years, domestic production in both countries is minimal and heavily reliant on overseas supply (Tridge, 2021). In 2019/2020, Germany and the UK were the highest net importers of fresh or chilled garlic in the EU region. While Germany only started to import fresh/chilled garlic from China in 2020, China has been the second biggest supplier of fresh/chilled garlic to the UK for many years.

3.3. MATERIALS AND METHODS

3.3.1. EU consumer survey data collection and sample description

An online panel provider recruited the participants and hosted the online data collection during April 2021. Target sample sizes were 250 participants from the UK and 250 participants from Germany. To qualify for the survey, participants had to be 18 years old or older and be responsible for purchasing processed garlic for themselves/their household at least 3-4 times per year. Processed garlic was defined as “garlic which has been chopped/sliced/minced/pureed, or dried (such as garlic flakes, garlic granules and garlic powder). Not whole bulbs or cloves”. ‘Speeders’ (those who had abnormally fast completion times) were removed by the online panel provider. The survey took approximately 15 minutes to complete and was approved (MHLS 21_30) by the Faculty of Medicine, Health and Life Sciences Research Ethics Committee at Queen’s University Belfast Ethical Committee.

3.3.2. Questionnaire design and outline

The master questionnaire was first developed in English by consumer scientists and then translated into German by bilingual researchers employed by the market research firm. Participants initially completed sociodemographic and purchasing items, and items relating to their baseline trust in the processed Chinese garlic chain (farmers and manufacturers) and the product itself. They were then presented with a description of Chinese garlic production and possible fraud (described in section 3.3.3), before being informed that they could obtain traceability information and an authenticity assurance for this product (described in section 3.3.4). Following this, and specific to traceable processed Chinese garlic with an authenticity assurance, they then completed items relating to trust in the product chain (farmers and manufacturers) and the product itself. Attitudes, beliefs, and purchase intentions (including willingness to pay) towards traceable Chinese garlic (vs standard Chinese garlic) were also captured.

3.3.3. Description of Chinese garlic production and possible food fraud



All participants read the following description of Chinese garlic production: “Did you know that around 80% of the garlic produced worldwide comes from China? And that the UK/Germany is the world’s 7th/8th biggest importer of fresh/chilled garlic?”

China produces around 23 billion kilograms of garlic a year. It is thought that this is grown by nearly 1.2 million farmers, across five major growing regions. After harvest, the garlic is sorted into three categories: garlic for the fresh market (60%), garlic for next years seed (20%) and garlic for processing (20%).

The garlic that has been graded for processing is bought by a collector who sells it onto a wholesaler. From there, the garlic is placed on a wholesale garlic market, where it is auctioned off and taken to a facility to be processed.

The garlic may physically pass through many different hands (and countries!) before it is even packed! Traders and brokers all over the world may arrange the purchase and sale of garlic along this chain. Traders and brokers are subject to very little regulatory oversight, and many will not have physical possession or ownership of the garlic they trade. As a result of these complex supply chains, **the consumer often knows very little about the history of the processed garlic (not even where it was grown!) and opportunities for food fraud are increased.**

Food fraud describes the deliberate adulteration of food with cheaper ingredients. Garlic powder, for example, has the potential to be mixed with any white powder – talc and chalk powder are possibilities, as well as starch.

Cheating can occur at any stage along the garlic supply chain: on the farm, during processing and packing, at the point of sale or somewhere in between. The main reason for food criminals to cheat is to mislead consumers and make a profit. These inferior products may contain hidden allergens (e.g., peanut) or ingredients which present a serious risk to human health.”

3.3.4. Description and pictorial example of traceable Chinese garlic with an authenticity assurance

Participants were informed about how spice businesses could obtain traceability information and an authenticity assurance for their Chinese garlic products. They were then shown an image which depicted how the products’ traceability information and an authenticity assurance might be communicated to them through a QR code on the products label. Essentially, we wished to portray that traceable Chinese garlic is “traceable from the ‘region of origin’ to the ‘supermarket shelf’ and has also been tested to verify that it is garlic”:

“Spice businesses can obtain **traceability information** and an **authenticity assurance** for their Chinese garlic products. For this to happen:

- the whole production process from “the region of origin” to the “supermarket shelf” is traced using high-end tracking technology, and
- the composition of the product is tested using food finger-printing techniques.

As a consumer, you can obtain additional information about farming practices and be informed about the **history** and movements of the garlic along the supply chain from its “region of origin”. You can also obtain an **assurance that the spice you are buying is authentically garlic.**



You can obtain this information by entering a code online or by scanning a QR code on the pack via your smart phone. Below is an example of what you might see. Please view the image (below) by clicking on it, then click 'continue' and 'next'."



Figure 1. How traceability information and an authenticity assurance might be displayed on a mobile phone. Please note in the German translation, the country of packing was Germany.

3.3.5. Questionnaire items

Items below were scored on a 7-point Likert-type scale (1 = “strongly disagree”, 7 = “strongly agree”), unless otherwise indicated.

Product trust: To measure product trust, participants responded to five statements per product. They indicated the extent to which they trusted that “processed Chinese garlic”/“traceable Chinese garlic”: “is good quality”, “is accurately labelled”, “is safe”, “has been subject to reliable and serious checks”, and “is actually garlic i.e., that food fraud tests would reveal that the garlic has not been substituted with something else”. Trust in processed Chinese garlic/traceable Chinese garlic had a Cronbach’s α of 0.95/0.97 and 0.96/0.98 for the German and UK samples, respectively.

Manufacturer trust: To measure manufacturer trust, participants responded to five statements per product. They indicated the extent to which “manufacturers of processed Chinese garlic”/ “manufacturers of traceable Chinese garlic”: “take good care of the quality of their products”, give special attention to the quality of their products, “are honest about the quality of their products”, “are sufficiently open regarding the quality of their products”, and “can be trusted to protect the consumer from low quality products”. This 5-item scale was inspired by five items (and their factor loadings) in the 7-item food chain trust scale developed by Benson et al. (2020). The same five items were used to measure trust in “farmers of processed Chinese garlic”/“farmers of traceable Chinese garlic” . Trust in manufacturers of processed Chinese garlic/



manufacturers of traceable Chinese Garlic had a Cronbach's α of 0.98/0.98 and 0.98/0.98 for the German and UK samples, respectively. Trust in farmers of processed Chinese garlic/farmers of traceable Chinese garlic had a Cronbach's α of 0.98/0.98 and 0.98/0.99 for the German and UK samples, respectively.

Attitude towards traceable garlic purchase: Attitude towards purchasing traceable Chinese garlic in comparison to non-traceable Chinese garlic was assessed by four semantic differential scales. Two scales tapped the affective aspect of attitude (i.e., "Buying traceable Chinese garlic instead of non-traceable Chinese garlic would make me feel": "bad–good", "displeased–pleased") while two scales tapped the cognitive aspect of attitude (i.e., "I think that buying traceable Chinese garlic instead of non-traceable Chinese garlic is": "harmful-beneficial", "foolish-wise". Items were scored on a 7-point Likert scale with higher scores indicating a more positive attitude. This scale had a Cronbach's α of 0.92/0.94 for the German and UK samples, respectively.

Belief towards traceable garlic purchase: To measure beliefs, participants responded to 10 statements that compared traceable Chinese garlic to non-traceable Chinese garlic (i.e., "Compared to non-traceable Chinese garlic, traceable Chinese garlic will likely be": "tastier", "stronger in flavour", "stronger in odour", "healthier (better for your health)", "more expensive", "safer", "more accurately labelled in terms of ingredients", "of better quality", "produced with safer labour practices", "produced with less sustainability issues"). This scale had a Cronbach's α of 0.94 for both the German and UK samples.

Intention to purchase traceable garlic: Intention to purchase traceable Chinese garlic over non-traceable Chinese garlic was assessed by three items (i.e., "When traceable Chinese garlic becomes available, I expect to buy it/I want to buy it/I intend to buy it over non-traceable Chinese garlic"). This scale had a Cronbach's α of 0.95/0.96 for the German and UK samples, respectively.

Willingness to pay for traceable garlic: Participants indicated how much more (as a percentage of the conventional products price) they would be willing to pay for traceable Chinese garlic granules in response to the following item: "suppose the price of non-traceable Chinese garlic granules currently available in the supermarket is £0.85/EUR 1.00 for a 56g jar/pack. The price of the traceable Chinese garlic granules is not yet determined yet. Would you pay any more? If so, how much more? Participants chose between the following response options: 0%, 5%, 10%, 15%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, and other please specify.

3.3.6. Data analysis

All analyses were conducted using IBM SPSS Statistics for Windows version 26.0 (IBM Corporation, Armonk, NY, USA). First, the demographic details and characteristics of the study sample were summarised with percentage frequencies. Scales were constructed by computing a mean of all items (scales ranged from a minimum of 1 to a maximum of 7) and descriptive statistics (means and SD) were calculated for all scales. Cronbach's α coefficients were used to assess the internal reliability of all study scales. Paired t-tests were used to compare trusts (product, manufacturer, and farmer) in processed Chinese garlic vs traceable Chinese garlic within both countries. A MANOVA was then used to identify differences between countries for each dependent variable (i.e., change in product trust; change in manufacturer trust and change in farmer trust). Attitudes, beliefs, and purchase intentions (including willingness to pay) towards traceable Chinese garlic (vs non-traceable Chinese garlic) were also compared (independent t-tests) by country.

3.4. RESULTS



3.4.1. Demographic summary

Demographic details and characteristics of the N = 570 participants are detailed in Table 1. The total sample had approximately equal numbers of males and females. The majority of participants in the total sample were aged 55-64 years (40.2%), had completed secondary/further education (50.9%), were working full-time (57.0%), purchased garlic powder as the most popular processed garlic product (61.8%) and purchased processed garlic once a month (23.5%).

Table 1. Demographic details and characteristics of the survey participants (N = 570).

	Total N = 570 %	UK n = 280 %	Germany n = 290 %
Gender			
Male	50.7	48.2	53.1
Female	49.1	51.8	46.6
Other	0.2	0.0	0.3
Age (years)			
18-24	2.5	2.9	2.1
25-34	9.5	7.1	11.7
35-44	19.8	16.1	23.4
45-54	24.9	25.4	24.5
55-64	40.2	43.6	36.9
65-74	3.2	5.0	1.4
Education			
No qualifications or compulsory level	16.7	23.9	9.7
Secondary/further education	50.9	36.8	64.5
University level	32.5	39.3	25.9
Occupation status			
Employed full-time (>30h per week)	57.0	50.0	63.8
Working part-time (≤29h per week)	15.4	17.5	13.5
Retired	12.8	14.6	11.0
Student	1.6	1.4	1.7
Unemployed	7.6	9.6	5.5
Full-time homemaker	5.6	6.8	4.5
Garlic purchased by participant			
Garlic bulbs	74.4	69.3	79.3
Garlic cloves	40.4	32.9	47.6
Garlic paste or puree	41.6	53.6	30.0
Chopped garlic	25.6	30.0	21.4
Garlic granules	48.6	45.7	51.4
Garlic flakes	18.6	19.3	17.9
Garlic powder	61.8	56.8	66.6
Frequency of purchasing processed garlic (not whole bulbs/cloves)			
More than once a week	20.9	6.1	35.2
Once a week	11.4	11.8	11.0
Once every two weeks	14.2	17.1	11.4



Once a month	23.5	27.5	19.7
Every two months	17.0	22.1	12.1
Every three/four months	13.0	15.4	10.7

3.4.2. Consumer preferences for traceability/authenticity information on processed garlic

The majority (87%) of participants did not purchase processed garlic based on where it is grown. Of those who did buy processed garlic based upon where it is grown, only n = 11 participants named China as their growing origin of choice. When all participants were asked to consider which country was most likely to have grown their processed garlic, the eight most popular answers were: China (24%), followed by France (17%), Turkey (10%), Italy (10%), Germany (8.6%), Spain (7.4%), India (7.2%), and the United Kingdom (6.0%).

When participants were presented with a list of attributes that could be labelled on processed garlic (Figure 2), the vast majority (90%) agreed that they would like to know “that it is actually garlic” they are purchasing. Around four in ten participants agreed that they would like to know details about processing (43%) and farming (42%) practices and be informed about the product’s journey from where it was grown to the supermarket shelf (41%). Almost four in ten participants wanted to know where the garlic was processed (38%), packed (38%) and grown (36%).

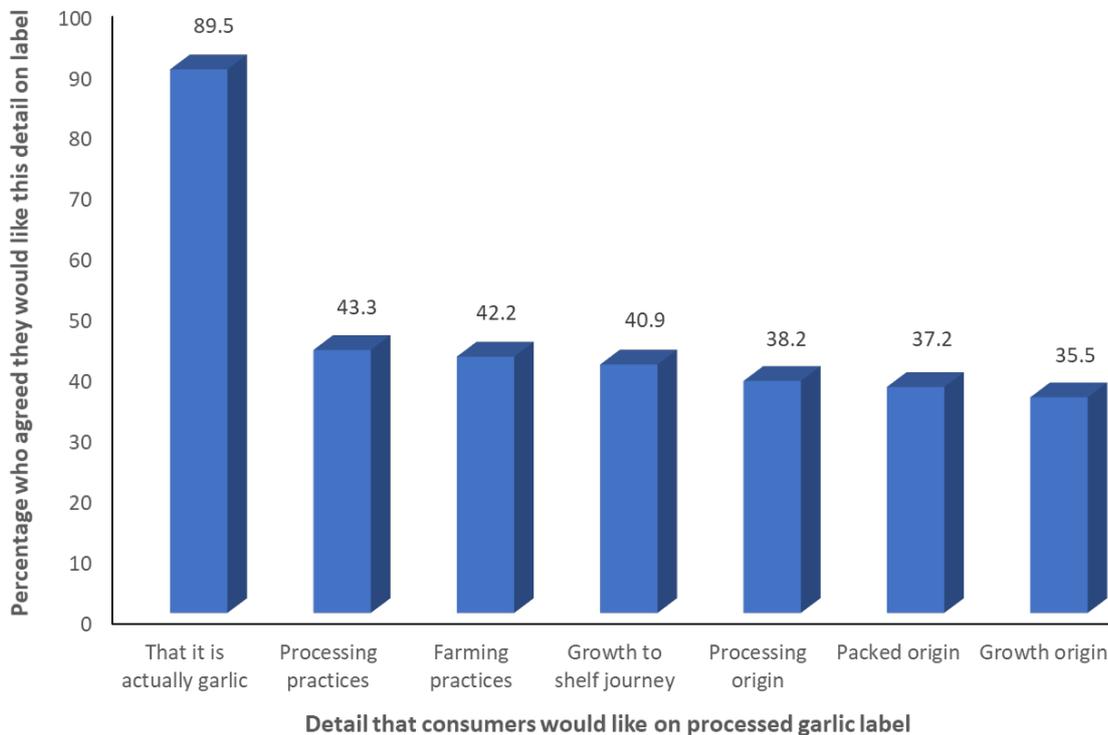


Figure 2. Details requested on the label of processed garlic.

3.4.3. Attitudes, beliefs and purchasing intentions towards traceable Chinese garlic with an authenticity assurance



Participants in each country reported a general favourable attitude with positive beliefs toward traceable Chinese garlic with an authenticity assurance. They viewed that buying traceable Chinese garlic, in comparison to the non-traceable product, would be wise/beneficial and make them feel good/pleased. The most positive beliefs were that the traceable product would be more accurately labelled, safer, of better quality, and healthier (all items scored above 5 in each country). At the same time, participants from the UK (vs Germany) expressed a significantly more favourable mean score in their attitude and beliefs towards traceable Chinese garlic.

While participants thought that the traceable product would be more expensive than a non-traceable product, high purchase intentions towards the traceable product were reported for both the German and UK sample (5.27 and 5.45, respectively, $p = 0.17$). Among participants, 73% of the German sample and 78% of UK sample agreed that they intended to purchase the traceable product once it becomes available, while others were neutral (12% and 11% for participants from Germany and the UK, respectively) or in disagreement (15% and 11% for participants from Germany and the UK, respectively).

Participants from the UK and Germany were most willing to pay 10% extra for traceable Chinese garlic (Figure 5). 17% of UK participants were unwilling to pay any price premium, while 70% would be willing to pay a 5 – 20% price premium. 19% of German participants were unwilling to pay any price premium, while 53% would be willing to pay a 5 – 20% price premium. Notably, 15% of participants from Germany would pay 50% extra but very few participants in either country (3% of UK participants and 4% of German participants) were willing to pay more than 50% extra.

Table 2. Mean (SD) of attitudes, beliefs and purchasing intentions towards traceable Chinese garlic per country. Items were scored on a 7-point Likert-type scale (1 = “strongly disagree”, 7 = “strongly agree”, unless otherwise indicated).

	Germany	UK
	n = 290	n = 280
	Mean (SD)	Mean (SD)
Attitude towards traceable Chinese garlic (4 items)¹	5.30 (1.38)	5.68 (1.21)**
<i>Buying traceable Chinese garlic instead of non-traceable Chinese garlic would make me feel...</i>		
Scale: bad (1) – good (7)	5.13 (1.55)	5.48 (0.33)
Scale: displeased (1) – pleased (7)	5.15 (1.58)	5.59 (1.29)
<i>I think that buying traceable Chinese garlic instead of non-traceable Chinese garlic is...</i>		
Scale: harmful (1) – beneficial (7)	5.37 (1.51)	5.81 (1.33)
Scale: foolish (1) – wise (7)	5.56 (1.56)	5.84 (1.31)
Beliefs toward traceable Chinese garlic (10 items)²	4.93 (1.24)	5.17 (1.19)*
<i>Compared to non-traceable Chinese garlic, traceable Chinese garlic will likely be...</i>		
tastier	4.64 (1.44)	4.94 (1.44)
stronger in flavour	4.72 (1.51)	5.00 (1.45)
stronger in odour	4.72 (1.48)	4.84 (1.34)
healthier (better for your health)	5.03 (1.51)	5.20 (1.54)
more expensive	5.14 (1.46)	5.30 (1.40)
safer	5.21 (1.59)	5.56 (1.47)
more accurately labelled in terms of ingredients	5.22 (1.52)	5.55 (1.41)
of better quality	5.20 (1.53)	5.46 (1.49)
produced with safer labour practices	4.85 (1.57)	5.05 (1.52)
produced with less sustainability issues	4.58 (1.60)	4.84 (1.48)



Intention to purchase traceable Chinese garlic (3 items) ³	5.27 (1.54)	5.45 (1.44)
<i>When traceable Chinese garlic becomes available...</i>		
I expect to buy it over non-traceable Chinese garlic	5.20 (1.62)	5.33 (1.53)
I want to buy it over non-traceable Chinese garlic	5.30 (1.63)	5.52 (1.45)
I intend to buy it over non-traceable Chinese garlic	5.32 (1.59)	5.50 (1.50)

*p = 0.018; ** p = 0.001; significant difference between countries.

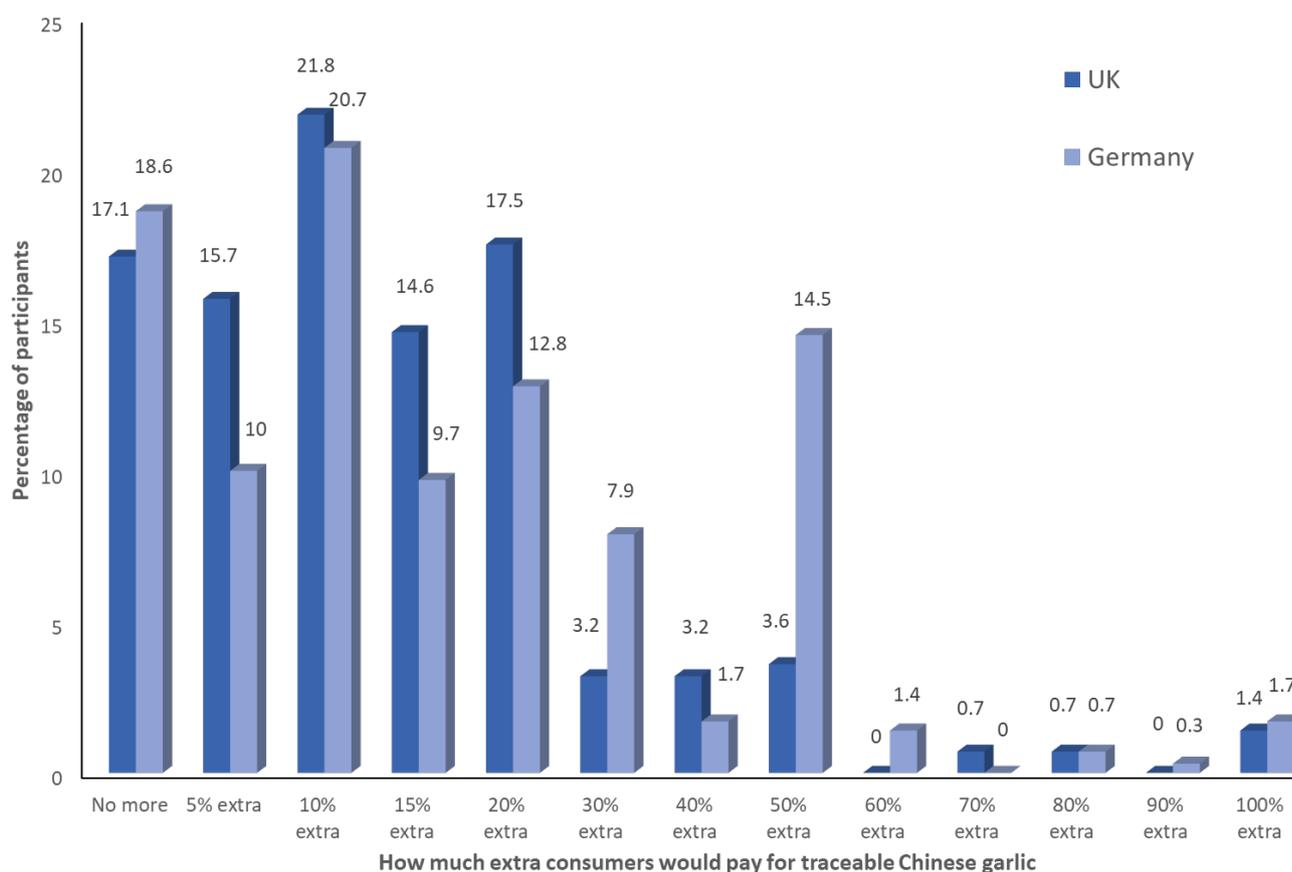


Figure 5. Willingness to pay extra for traceable Chinese garlic with an authenticity assurance.

3.4.4. Trust in processed garlic and traceable processed garlic with an authenticity assurance

All three types of trust (product, manufacturer, and farmer) were significantly ($p < 0.001$) greater per country following the provision of traceability information with an authenticity assurance (Figure 2, 3 and 4). The increase in product trust for UK participants was significantly ($p > 0.001$) greater than the increase in product trust for German participants (0.79 vs 0.37 for UK and German participants, respectively). Of note, UK participants (vs German participants) had significantly lower baseline trust ($p = 0.003$). The increase in manufacturer trust and farmer trust did not significantly differ ($p > 0.001$) between countries.

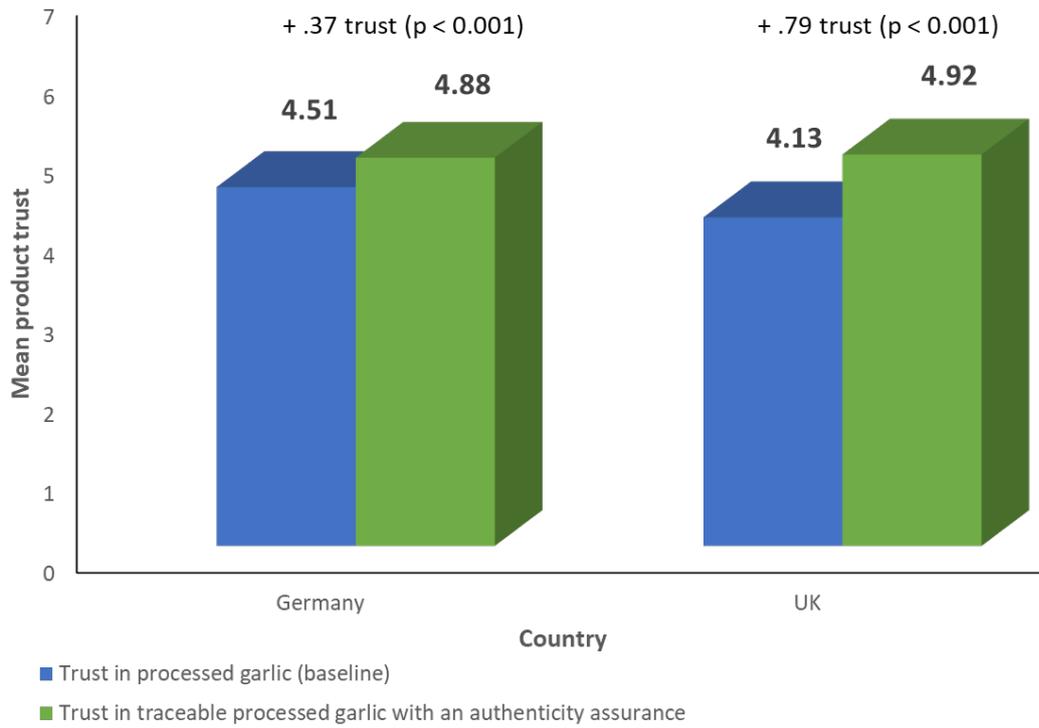


Figure 2. Change in mean product trust following the provision of traceability information with an authenticity assurance.

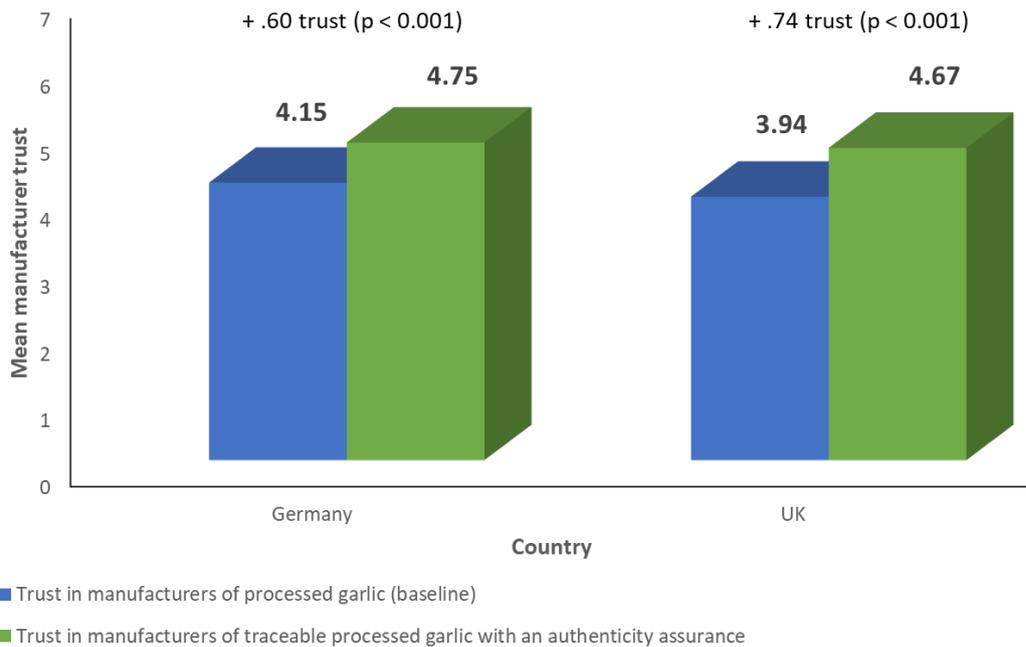




Figure 3. Change in mean manufacturer trust following the provision of traceability information with an authenticity assurance.

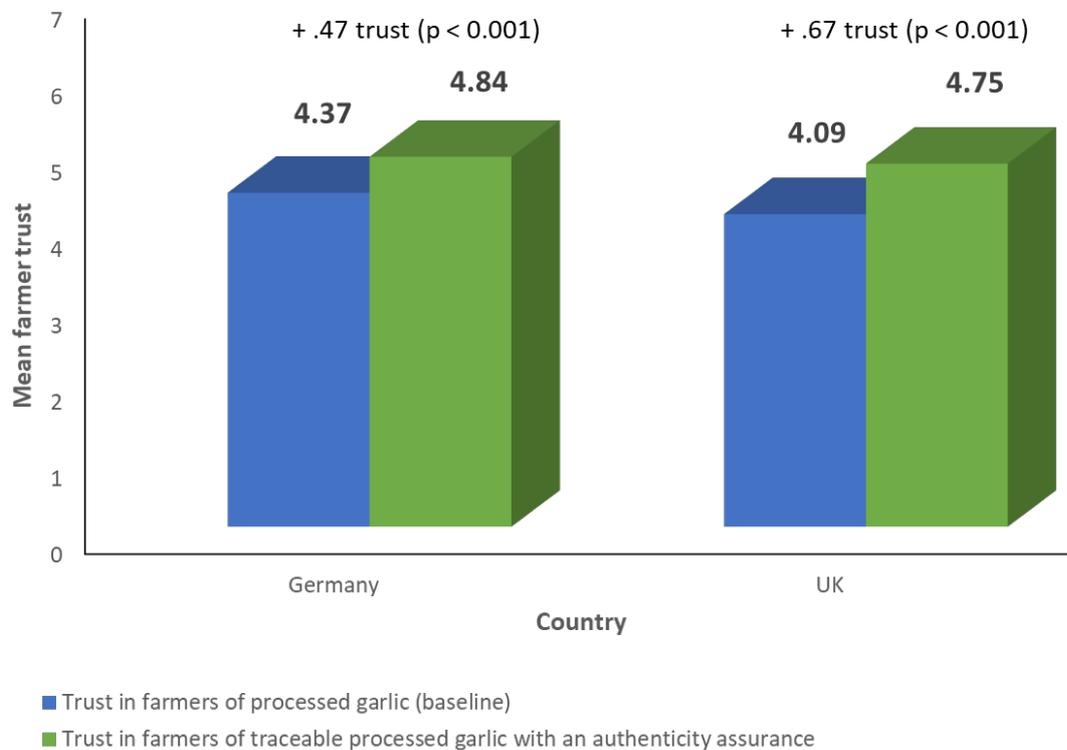


Figure 4. Change in mean farmer trust following the provision of traceability information with an authenticity assurance.

3.5. CONCLUSIONS

The objectives of this study were first to explore consumer preferences for traceability and authenticity information in relation to processed Chinese garlic. Second, to explore consumer attitudes, beliefs and purchasing intentions towards traceable Chinese processed garlic with an authenticity assurance. Third, to investigate if traceability information and an authenticity assurance can improve consumer trust in Chinese processed garlic and its manufacturers/farmers. We chose to explore consumer perceptions in two markets: Germany and the UK.

3.5.1. Consumer preferences for traceability information and an authenticity assurance

This survey study has shown that most consumers did not purchase garlic based upon where it was grown, however, 4 in 10 participants wanted to know more about its history and most (90%) agreed that they would like an authenticity assurance i.e., to know “that it is actually garlic”.



Focus group (FG) participants had great trust in products which originated within the EU. They recognised that food rules, standards and certifications in this region were the most stringent in the world, however, some were not as confident in the quality/safety of foods on sale within the EU that had originated (or were grown) outside of the EU. UK participants feared that food quality/safety would suffer as a result of BREXIT as products would increasingly be sourced from external markets which were not as strict in terms of food law or its governance. Extra information and checks were viewed as desirable for some foods; especially for products originating outside of the EU, of high value, or those that had proved to be susceptible to fraud in the past:

Quote: *“I think it would be beneficial for foods like meat, to know where it came from, what factory it went from. Because you don’t always get the true picture from farm to shop.*

3.5.2. Consumer attitudes, beliefs, trusts and purchasing intentions towards food with traceability information and an authenticity assurance

In the literature, there has been little consideration given as to how food fraud technologies are perceived by consumers. In this survey study we explored consumer perceptions in relation to traceable processed Chinese garlic with an authenticity assurance. The provision of traceability information with an authenticity assurance increased trust in the product and chain actors (farmers and manufacturers). Participants viewed that buying traceable and authentic processed Chinese garlic would be wise/beneficial and make them feel good/pleased. They also reported more positive perceptions of the product over untraceable garlic and unauthentic garlic (more accurately labelled, safer, of better quality, healthier, etc.) and there was a positive intention to purchase it. Consumers were willing to pay a premium for authentic and traceable garlic; typically, up to 10% extra but sometimes higher.

FG participants viewed that traceability and authenticity assurances on product labels were a positive development, which would increase their trust in the product. Assurances such as these would elicit a price premium if it authenticated an attribute of particular importance to them, especially if it was one for which they were already paying a premium for e.g., organic food. They did not envisage that they would check the QR code on every purchase, however, the mere presence of a QR authenticity/traceability code on a label would serve as an indicator of quality, much like a certification scheme. Overall, participants were unfamiliar with food fraud technologies so their benefits would need to be communicated. For a system to be trustworthy, they stressed that it must not be company-owned/governed. This would be an important aspect in relation to the communication around such a scheme.

3.5.3. Country differences

UK participants did differ from German participants in a few ways. Specifically, the provision of traceability information with an authenticity assurance increased product trust more in the UK sample. However, there was no significant difference in the increase of trust in the manufacturers or farmers within the countries (both increased similarly), and the German sample had higher baseline product trust (compared to the UK sample). Participants from the UK (vs Germany) also expressed a significantly more favourable mean score in their attitudes and beliefs towards traceable Chinese garlic.

Assuring the traceability and authenticity of food does come at an additional cost, however, these costs must be weighed against all potential benefits. EU Consumer responses to traceable processed garlic with an



authenticity assurance are positive and technologies such as these may be a worthwhile investment for spice manufacturers selling within the EU market, especially those who source outside of the EU.

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4. THE PROVISION OF RECOMMENDATIONS TO INDUSTRY FOR IMPROVED CONSUMER COMMUNICATION OF EU PRODUCTS TO CHINA

Three key recommendations to industry for improved consumer communication of EU products to China are outlined below:

- Manufacturer trust is a strong predictor of purchasing intention. As such, manufacturing needs to be seen (by the Chinese consumer) to be visible, traceable (from the raw material to the finished product as a minimum), compliant and risk accountable.
 - Visible: e.g., Chinese consumers being able to visit the factory (at least digitally) to see the production process.
 - Traceable: e.g., Chinese consumers being informed about the origin of raw materials.
 - Compliant: e.g., inspection results made known to the Chinese consumer.
 - Risk accountable: e.g., able to justify actions to the Chinese consumer and accept responsibility.

These actions are proof that manufacturers not only care about the food they produce, but that they are also open, honest, and protective of consumers.

- Technological advances (e.g., block-chain based traceability) and laboratory advances (especially the use of detection methods in the authentication of food) have an additional role to play in improving consumer trust in high-end foods (e.g., infant milk formula, wine, Whisky) and contribute to brand protection. As a result, Chinese consumers are prepared



to pay a premium for trustworthy traceability information/authenticity assurances. However, consumer demand for specific assurances (e.g., origin) must first be in place.

- Communications should serve to reassure consumers about the robustness of the technology/science behind such information/assurances. The involvement of independent, 3rd parties in overseeing the information/assurance is viewed positively by consumers.

RECOMMENDATIONS TO INDUSTRY FOR IMPROVED CONSUMER TRUST IN EU PRODUCTS TO CHINA



Feeding Bottle on Table, by Burst, Source: <https://www.pexels.com/photo/bottle-container-high-chair-macro-374756/>, Licensed under CC0

In Europe and China, consumer trust in the food industry and regulatory authorities has been damaged by a large number of accidental and deliberate food contamination and food fraud incidents.

WHAT IS FOOD FRAUD?

“Food fraud is committed when a food is misdescribed with the intention of deceiving the consumer for financial gain”. This means that the origin of food, its composition and/or how it was obtained/prepared may not be truthful.

There are many types of food fraud, for example:

- counterfeiting – copying the brand name, packaging etc.
- mislabelling – making a false claim on the packaging.
- substitution – replacing part of the product (or an ingredient) with something cheaper.
- unapproved enhancement – adding unknown materials to improve quality.

Often, when people talk about food fraud, they may refer to the food as being ‘fake’.

WHY IS CONSUMER TRUST IMPORTANT?

While consumer trust is essential to any market, it is particularly relevant to the food market. Consumers expect foods available for purchase to be safe and of satisfactory quality. If a consumer trusts and therefore unknowingly purchases and consumes an inauthentic or unsafe product, this may lead to consequences ranging from a poor sensory experience through to illness or death. More than ever, consumers want to know the source of their food and how it was grown, handled, shipped, produced, and packaged, with traceability and transparency being key trends (Lu, Wu, Wang, & Xu, 2016).



RECOMMENDATIONS TO INDUSTRY FOR IMPROVED CONSUMER TRUST IN EU PRODUCTS TO CHINA



ENHANCING CONSUMER TRUST

Traceability and transparency are promising potential solutions to increase consumer trust. A system of convincingly highlighting and guaranteeing the origin and traceability of EU infant formula milk (IFM) to consumers in a transparent way is a worthwhile investment for European exporters.

Some examples:

Method 1 (tracked) – Authentication of geographic origin and tracked product journey – shows where the formula was manufactured and the product's journey through the supply chain.

Method 2 (tested) – Testing at home to reveal the geographic origin of the formula.



Infant Formula, by the National Institute of Korean Language, Source: <https://commons.wikimedia.org/w/index.php?search=infant+formula&title=Special:MediaSearch&go&type=image>, Licensed under CC BY-SA 2.0 KR

FINDINGS

Trust in tracked and tested EU IFM manufacturers was statistically higher than in domestic IFM manufacturers.

Willingness to pay for tracked/tested EU IFM: The highest price that participants would be willing to pay for the tracked EU IFM was the same as the tested IFM.

Product preference (tracked or tested EU IFM): The majority of consumers preferred the tracked EU IFM. 38.6% of consumers preferred the tested EU IFM which rose to 43.7% when they could purchase the scanning device required for the tested EU IFM.

Overall, Chinese consumers viewed a system of convincingly guaranteeing the geographic origin of IFM from the EU to be beneficial/important/essential. The most positive belief connected with origin assured EU IFM is the belief that it will improve the safety of the product, followed by the beliefs that it will improve the quality of the product and be beneficial for infants. An origin guarantee would also benefit the EU (reputation, economy) and improve trust in both EU manufacturers and Chinese stakeholders (retailers, regulators, and the government).



RECOMMENDATIONS TO INDUSTRY FOR IMPROVED CONSUMER TRUST IN EU PRODUCTS TO CHINA



THREE KEY WAYS FOR INDUSTRY TO IMPROVE CONSUMER TRUST OF EU PRODUCTS TO CHINA

1. *Manufacturer trust is a strong predictor of purchasing intention.* As such, manufacturing needs to be seen (by the Chinese consumer) to be visible, traceable (from the raw material to the finished product as a minimum), compliant and risk accountable.

- Visible: e.g., Chinese consumers being able to visit the factory (at least digitally) to see the production process.
- Traceable: e.g., Chinese consumers being informed about the origin of raw materials.
- Compliant: e.g., inspection results made known to the Chinese consumer.
- Risk accountable: e.g., able to justify actions to the Chinese consumer and accept responsibility.

These actions are proof that manufacturers not only care about the food they produce, but that they are also open, honest, and protective of consumers.

2. *Technological advances* (e.g., block-chain based traceability) *and laboratory advances* (especially the use of detection methods in the authentication of food) have an additional role to play in improving consumer trust in high-end foods (e.g., infant milk formula, wine, Whisky) and contribute to brand protection. As a result, Chinese consumers are prepared to pay a premium for trustworthy traceability information/authenticity assurances. However, consumer demand for specific assurances (e.g., origin) must first be in place.

3. *Communications* should serve to reassure consumers about the robustness of the technology/science behind such information/assurances. The involvement of independent, 3rd parties in overseeing the information/assurance is viewed positively by consumers.

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