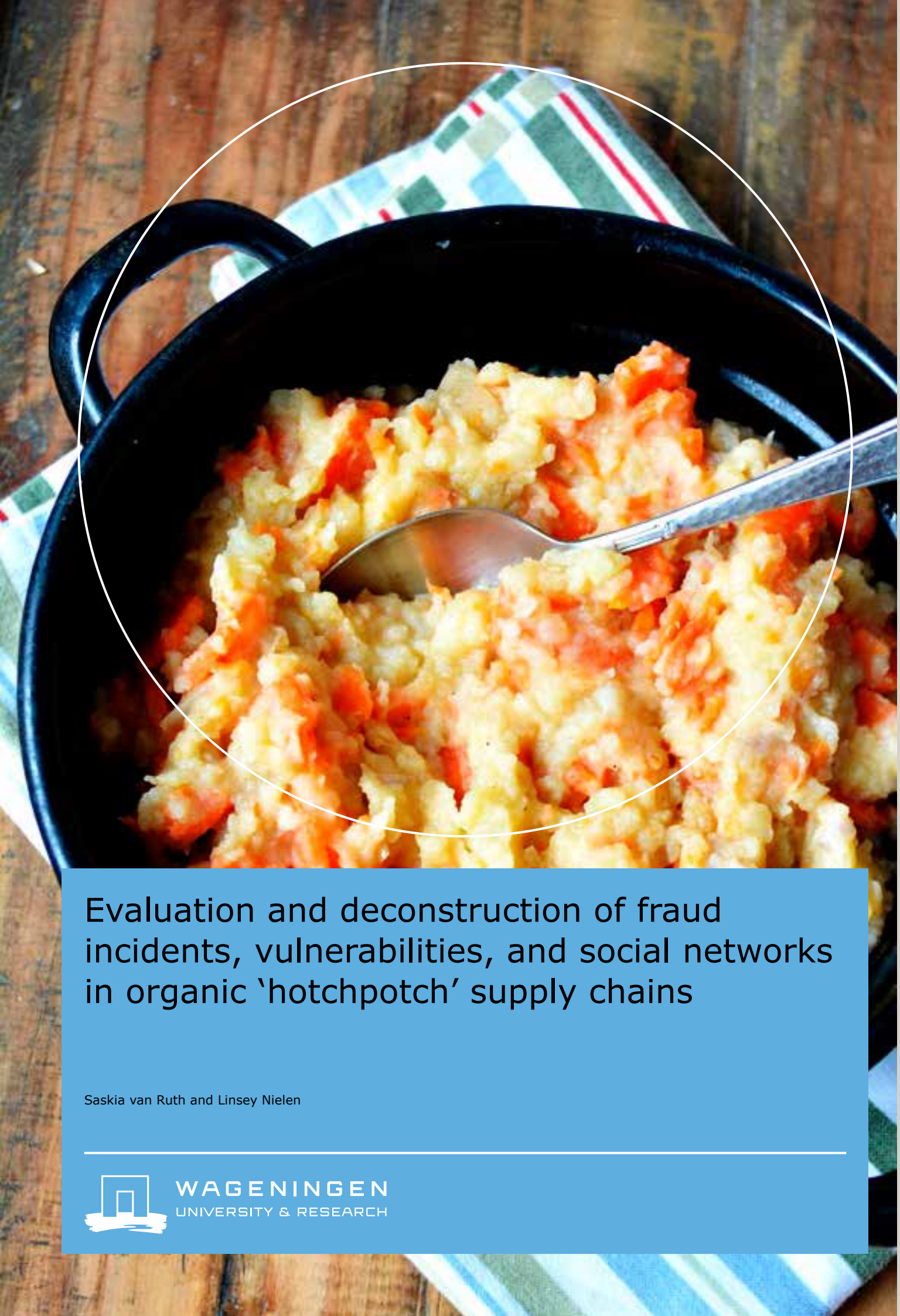

Evaluation and deconstruction of fraud incidents, vulnerabilities, and social networks in organic 'hotchpotch' supply chains

Saskia van Ruth and Linsey Nielen

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Evaluation and deconstruction of fraud incidents, vulnerabilities, and social networks in organic 'hotchpotch' supply chains

Report on fraud incident reports, vulnerability assessments, and social network analysis in the Dutch organic potatoes', carrots', and onions' supply chains

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This research has been carried out by Wageningen Food Safety Research, institute within the legal entity Wageningen Research Foundation subsidised by the Dutch Ministry of Agriculture, Nature and Food Quality (project number WOT-02-005-60).

Wageningen, December 2022

WFSR Report 2022.023

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van Ruth, S.M., L. Nielen, 2022. *Evaluation and deconstruction of fraud incidents, vulnerabilities, and social networks in organic 'hotchpotch' supply chains; Report on fraud incident reports, vulnerability assessments, and social network analysis in the Dutch organic potatoes', carrots', and onions' supply chains.* Wageningen, Wageningen Food Safety Research, WFSR Report 2022.023. 50 pp.; 4 fig.; 7 tab.; 26 ref.

Project number: 1277352201
BAS-code: WOT-02-005-60
Project title: Voedselfraude (Food fraud)
Project leader: Saskia van Ruth

This report can be downloaded for free at https://doi.org/10.18174/579487 or at www.wur.eu/food-safety-research (under WFSR publications).

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WFSR report 2022.023

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Contents

Summary

This study aims to create a greater understanding of (1) existing unlawful food fraud activity, (2) food fraud vulnerabilities and (3) related network structures within the organic potatoes', carrots', and onions' supply chains. Three types of methodology were applied to meet the aims: (1) an analysis of historical prevalence and patterns of food fraud in the organic sector in general and in the three selected organic chains, (2) a food fraud vulnerability analysis of supply chain actors of the three specific organic supply chains in the Netherlands, and (3) a social network analysis to identify structural characteristics of the three organic supply chains in the Netherlands. Incident analysis using the Decernis food fraud database revealed 201 incidents with organic foods between 2004 and 2021, 47 of which had a food safety component. Most targeted products were plant-based. Key products were fruits (42 cases), cereals and pulses (38 cases), spices/herbs/flavourings (20 cases), vegetables (19 cases), processed food products (14 cases: juice, oil, jam, infant food, tomato paste, wine, etc.), seeds (13 cases), and coconut products (12 cases). Only two organic potatoes', one organic carrots', and two organic onions' incidents were identified in the database. Food fraud vulnerability assessments revealed that the vulnerabilities of the organic potatoes', carrots', and onions' chains to food fraud were fairly like each other, at a low to moderate level. This level was comparable to the level of the previously examined organic bananas' chains and less vulnerable than the previously examined organic olive oil, eggs', and pork chains. This all aligns with the low frequency of fraud incidents in the three organic food chains in the Decernis food fraud database. Because of the similarity in food fraud vulnerability level of the three chains under investigation, one supply chain, the organic potato supply chain, was selected for social network analysis. This analysis revealed three distinctive groups among the actors in this supply chain: (A) a group with many contacts within the potato growers' group, (B) a group with many contacts across all the organic potato supply chain nodes, and (C) a group with mainly contacts outside the chain. The actors of the three groups have distinctively different interactions and would, hence, also have potentially different roles in food fraud events. Socially key actors could also be identified. Although the food fraud vulnerabilities in the Dutch organic potato supply chain are limited, the social network analysis provides very useful information for future work. Given that this is the first time such an approach has been taken in a national food fraud context, identification, and visualisation of key actors from a social network point of view in this particular chain will be useful for comparison with other food supply chain networks in future research.

1 Introduction

The global organic food market is currently estimated at a value of 80 billion euro, demand has been growing rapidly and a global growth of approximately 15% annually is predicted for the next five years [1]. Organic food products retail at a higher price than their conventional counterparts which is a strong economic driver for fraud. Furthermore, it is virtually impossible to distinguish organic from conventional produce visually, but even with current analytical technologies authentication remains a challenge for the majority of the products. These difficulties in detection reduce the options to monitor the authenticity of products along the chain. The economic drivers and complexities of controls lead to some organisations being tempted to outsmart customers and replace or adulterate organic products. These illicit activities do not only deceive consumers who pay for products they do not get, and pay for products they do not want, but they also harm organic farmers who are playing by the rules and cannot compete with the lower prices usually offered. This causes incalculable damage to the confidence consumers have in organic products. Although frauds with organic food products surface frequently, not all actors are similarly vulnerable to internal and external threats. Previously we have studied the vulnerability of a number of organic food supply chains, i.e. the organic bananas', eggs', olive oil, and pork supply chains. After consultation with SKAL, the certifying organisation for organic productions in the Netherlands, and the Department of Agriculture, Nature, and Food Quality of the Netherlands, interest was indicated in additional, more locally focused supply chains: Potatoes, carrots, and onions, the so-called hotchpotch ingredients ('hutspot' in Dutch). In the current study, we will focus on these three supply chains. However, we will also broaden the set of methodologies compared to our previous work. For some aspects the three commodities and their supply chains will be compared to other chains, where feasible.

This study aims to create a greater understanding of existing unlawful activity within this sector and future integrity challenges. Research will be conducted through a range of methodologies: (1) an analysis of historical prevalence and patterns of food fraud in the organic sector, (2) a bird's eye view on food fraud vulnerability analysis of supply chain actors, and (3) a social network analysis to identify structural characteristics of the organic supply chains studied. These studies will help to provide insight into the current prevalence of food fraud in the organic supply network, its most vulnerable points, factors contributing to vulnerability, the structure of the social network in the chain, and whether these chains are structurally vulnerable to future fraudulent activity.

Although we will start with an incident analysis in organic food supply chains as a benchmark, it is known that much fraud is under-reported. So, whilst data from a prevalence study will provide insights into the scope and geographic spread, it is likely to present a relatively conservative picture compared to the actual extent of the problem. Therefore, we are also applying alternative methods to understand how and where a supply chain might be exposed to fraudulent opportunity [2]. Vulnerability assessments have been conducted in European supply chains for various sectors and provide insight into which fraud factors contribute to overall fraud vulnerability and how vulnerability might differ between actor groups, regional location, or product types [3-9]. Social network analysis has been used in predictive policing to understand how criminal relationships, behaviours, and processes influence fraud opportunity. Social network analysis is used to examine individual behaviour, the structure of relationships between actors and their interactions in the supply chain. Crime script analysis, often used in tandem with social network analysis to understand the connections between actors, maps out the specific sequential steps, skills and resources required for such a crime to take place [10] and these tools are emerging as a methodology to analyse food fraud. Several studies have employed social network analysis to increase the understanding of network characteristics and structural conditions that facilitate illegal behaviour: e.g., the analysis of counterfeit alcohol investigations [11], to increase understanding of criminal behaviour in a soft drinks' fraud [12] and to propose local and macro-level intervention strategies to prevent illegal fishing [13]. Using this approach to identify potential points of deception in a supply chain may provide novel insights that can be used for food fraud prevention and mitigation strategies.

2 Methodology

2.1 Incident report analysis

This study examined reported food fraud in the Decernis Food Fraud Database [14] which were interrogated for fraud incidents with organic food products from 2004 till June 2021 (no records between 1980-2004 listed) and analysed according to date, type of product, type of product group at aggregated level, country of production, and country of distribution.

2.2 Food fraud vulnerability assessments

Wageningen University & Research and VU University of Amsterdam developed a food fraud theoretical framework to understand factors contributing to the vulnerability to fraud in supply chains [2]. The concept is based on the criminological routine activities' theory [15], and science-based key food fraud vulnerability factors have been identified. Opportunities, motivations, and control measures are defined in this framework as the three main elements of food fraud vulnerability. They can be subdivided into technical opportunities, opportunities in time and place, economic drivers, cultural and behavioural drivers, as well as technical control measures and managerial control measures. Food fraud vulnerability threats may originate from both the external and the internal environment of a business which means that several vulnerability factors need to be considered at multiple environmental levels, i.e., the level of the business itself, its suppliers, its customers, the wider chain, and at the (inter)national level [2]. The concept was further developed into a practical food fraud vulnerability self-assessment tool with 50 questions and answering grids, the SSAFE food fraud vulnerability self-assessment tool (SSAFE FFVA tool) [16], which is currently widely applied in the food industry. The tool is also valuable to assess vulnerabilities between supply chains, differences between nodes in the same supply chain and between tiers across supply chains. This provides insights in the overall vulnerability of chains but also provides information on critical points in chains. This information can in turn be used for understanding food fraud for academic purposes but also as input for fraud risk-based monitoring. The tool was recently modified to allow assessments from a bird's eye view perspective for regulatory agencies rather than being used as a self-assessment by a food business operator. This resulted in a questionnaire comprising 30 indicators, which is presented in Annex 1.

The three organic supply chains, i.e., ware potatoes, carrots, and onions, were assessed for their vulnerabilities using the adapted bird's eye view assessment. Based on literature and additional internet findings as well as information collected from stakeholders (actors, certifying bodies, scientists) the situation that best suited the practical situation in the supply chains was selected for each indicator. All selected answering options were converted to low, medium, and high vulnerability responses. To facilitate interpretation, responses to different groups of the questions of the SSAFE FFVA tool were considered in the evaluation. In accordance with the food fraud theoretical framework on which the SSAFE FFVA is based, questions related to each of the three key fraud elements opportunities (Q1-7), motivations (Q8-17) and control measures (Q18-30) were grouped.

The results were collated and results from previous studies on organic supply chains converted into the 'bird's eye view variant' to allow comparison with other organic supply chains, i.e., the organic bananas, eggs, olive oil, and pork chains.

2.3 Social network analysis

2.3.1 Methodology

Social network analysis is a summary procedure that allows for the systematic description of interactions among individuals, groups, and/or organisations [17]. To perform a social network analysis, data on the interactions of individuals or organisations need to be collected [18]. The data obtained can then be used to describe various aspects of collaboration. Data that can be used is the frequency, type, and strength of contacts. To carry out a social network analysis, questionnaires and interviews can be used to gather information on the relationships between the actors in a chain [18-19]. In the current study, a questionnaire was supplied to actors in the organic potato supply chain. The questionnaire started with some introductory text stating the approximate duration of the questionnaire, that the responses would be processed anonymously and that completing of the questionnaire was entirely voluntarily. The text further stated that if the participant did not work in the organic potato supply chain, they were requested not to fill in the questionnaire. The participant had to give his/her informed consent to continue with the questionnaire.

The first question asked was to enquire whether the participant worked with organic potatoes. If this was not the case, the participant was redirected to the end of the questionnaire. When the participant did work with organic potatoes, the next question related to the kind of business (s)he worked in. Subsequently, the participants were requested to indicate for every actor group, i.e., organic potato grower, organic packaging company, wholesaler, and supermarket/retailer, whether they have no contact, little contact, regular contact, or frequent contact with them in the context of their work. In addition, the participant was asked to specify what kind of activities existed between the participant and the indicated companies. Furthermore, interviewees were asked if there were other companies with which the participant had frequent contacts in the context of their work. If the answer was yes, there was another question about the activities that were taking place between the participant and the indicated company. At the end of the questionnaire, two questions about fraud in the organic potato supply chain were posed. Firstly, a question about the ease of fraud in the organic potato supply chain. The second question concerned an estimate of how often fraud in the organic potato supply chain in the Netherlands occurs according to the interviewee. Both questions were answered on a line-scale from 1 to 100. After all the questions had been answered, the participant was thanked, and the questionnaire ended. The questionnaire (in Dutch) and the scores associated with the various answers are presented in Annex 2.

2.3.2 Selection of participants

The targeted participants of the study were people working in the organic potato production chain. First, a Google search was carried out to find organic potato growers, processors, traders, sellers, or other companies working in this field. Subsequently, the Dutch Chamber of Commerce (Kamer van Koophandel) register was searched for ‘organic potato’. Finally, listings of Skal certified companies were cross-checked against organic potato production. For all the companies that were found active in the organic potato production chain, an e-mail address was noted. After the list of email addresses was completed, the questionnaire was mailed to 104 companies that were active in the organic potato production chain. After a few weeks, a reminder mail was sent to everyone who had not responded yet. Two-three weeks later, the last reminder was sent. In addition, the questionnaire was distributed via LinkedIn.

A total of 71 participants started the survey. However, not all of them completed the survey. Some of the participants did not give their informed consent (n= 4); some of the participants did not work with organic potatoes (n= 2) and some of the participants stopped the survey halfway through (n=21). As a result, a total of 44 participants completed the entire survey. However, eight of the participants who had not completed the entire survey had completed the main part of the survey. Namely, whether they had contact with the various companies in the production chain of organic potatoes. For this reason, it was decided to include the participants in the study. As a result, 52 participants were usable for the analysis. Of these participants, 67% worked as a potato grower, 2% in a packaging company, 8% as a wholesaler, 8% in a supermarket/retailer, 2% were grower, packaging company, and wholesaler in one, and 14% were sales points other than supermarkets, such as the market, a farm shop, a health food shop, a grocery service, or an online shop for organic products.

2.3.3 Data analysis

Contacts between actor groups were indicated by frequencies, and means and standard deviations (SD) were calculated. In addition to the given (stated) actors, the participant could also indicate whether (s)he has contact with other actors. To be able to collate these actors, the same answers were grouped together. The raw data, whether an actor was in contact with a certain actor group (yes/no) was used to develop a social network map using the free Gephi 0.9 software (www.gephi.org). Furthermore, a multiple correspondence analysis (MCA) was carried out to identify the most and least connected actors using XLSTAT (Addinsoft, Paris, France).

To be able to analyse the activities between the different actors, the answers of the open questions were grouped first and subsequently converted to frequencies.

For the questions about the ease of fraud in the organic potato supply chain and how often fraud in the organic potato supply chain in the Netherlands occurs, means of the line-scale scores were calculated. Moreover, a One-Way Analysis of Variance (ANOVA) was used to examine the significance of the differences of the answers of the various actor groups. A significance level of $p < 0.05$ was applied throughout the study.

3 Results and discussion

3.1 Incident report analysis

The Decernis food fraud database [14] is the most extensive food fraud database in the world. Two-hundred-and-one records on fraud incidents with organic produce were retrieved from the database and are listed in Table 3.1 (Period 2004-2021; Raw data in Annex 3). The number of incidents per year are presented in Figure 3.1. In the last decade, the number of incidents amount about twelve a year, and the data do not show an upward or downward trend in this period.

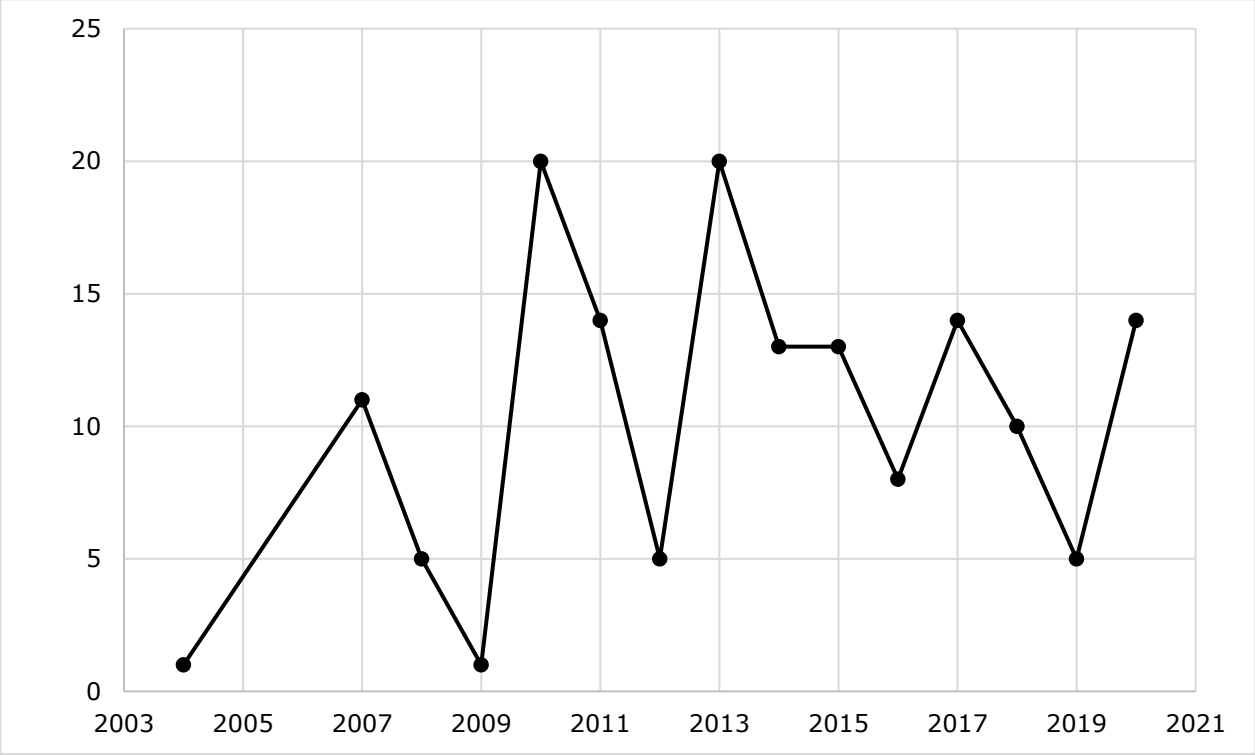

Figure 3.1 *Number of food fraud incidents concerning organic products per year listed in the Decernis food fraud database (some records given over multiple years have not been included).*

The most frequently listed type of individual products from high to low are corn (8 records), soybean (8 records), wheat (6 records), chia seeds (5 records), eggs (4 records), mango (3 records), vanilla powder (3 records), vegetables (3), and many other products with one or two records. At aggregated level, incidents can be grouped in decreasing order as follows: incidents with fruits (42), cereals and pulses (38), spices/herbs/flavourings (20), vegetables (19), processed food products (14: juice, oil, jam, infant food, tomato paste, wine, etc.), seeds (13), coconut products (12), nuts (9), sweeteners (9), cocoa/coffee (6), meat (5), eggs (5), and fish (3). It is remarkable that the great majority of incidents concerns products of plant origin and only a few of animal origin. Furthermore, mostly products in their primary, intact form (unprocessed) are listed. On the one hand, this kind of fraud may be picked up early in the chain, but on the other hand, it may also be the only kind of fraud that can be detected analytically. Assessment of the organic nature of a composite and/or processed product is extremely challenging.

Interestingly, for about a quarter (47/201) of the cases listed hazards were registered, which included unacceptable pesticide residue levels, expiration of products, tampered infant formula products, nuts regarding allergy issues, etc..

Regarding the place of production, most incidents have been reported from productions in Asia (71), followed by those in Europe (62), the Americas (40), Africa (21), and Oceania (4). For ~45% of the incidents, it is unknown where the products have been distributed. For those with listed locations, most ended up in Europe (170), and a few in the Americas (9), and Asia (3).

For organic potatoes, carrots, and onions are respectively two, one, and two incidents reported, which are presented in Table 3.2.

Table 3.1 *Records on fraud incidents with organic produce in the Decernis food fraud database (2004-June 2021).*

Product	Corn (8) Soybean (8) Wheat (6) Chia Seeds (5) Eggs (4) Mango (3) Vanilla powder (3) Vegetables (3) Agave syrup (2) Agave syrup crystals (2) Alfalfa (2) Almond (2) Apples (2) Avocado (2) Bell Pepper (2) Cashews (2) Chicken (2) Chili pepper (2) Cocoa Powder (2) Coconut milk (2) Coconut powder (2) Coconut water (2) Fruits (2) Ginger (2) Goji berry (2) Grapes (2) Hemp Seed (2) Millet (2) Onion (2) Oranges (2) Pistachio (2) Pork (2) Potato (2) Rapeseed (2) Sorghum (2) Sunflower seeds (2) Tomatoes (2) Vanilla extract (2) Acai (1) Agave inulin (1) Agave inulin powder (1) Alfalfa (1) Seed (1) Anchovies (1) Apple Juice (1) Apricot (1) Aronia (1) Bamboo shoots (1) Banana (1) Barley (1) Black beans (1) Blackberry (1) Blueberry (1) Bourbon vanilla extract (1) Broccoli (1) Brown sugar (1) Buckwheat (1) Burdock root (1) Carrot (1) Cereal (1) Cherries (1) Chocolate (1) Chocolate extract (1) Coconut (1) Coconut cream (1) Coconut flour (1) Coconut milk (1) Coconut oil (1) Coconut water (1) Cod (1) Coffee (1) Coffee (1) Collagen peptides powder (1) Cranberries (1) Eggs (1) Essential oils (1) Field beans (1) Field pea (1) Flaxseed (1) Fruit (1) Garlic (1) Gooseberries (1) Grain and seed products (1) Grains (1) Herbs (1) Honeydew melon (1) Infant formula (1) Jam (1) Leafy greens (1) Lemon (1) Lemon extract (1) Lemon Peel (1) Lingonberries (1) Macadamia nut (1) Mango (1) Meat (1) Mushroom Products (1) Mushrooms (1) Nuts (1) Oats (1) Olive oil (1) Orange extract (1) Oregano (1) Pasta (1) Pawpaw (1) Pineapple (1) Plum (1) Processed foods (1) Pumpkin (1) Raspberries (1) Redcurrants (1) Rice (1) Sardines (1) Sea buckthorn (1) Soy protein concentrate (1) Soy protein isolate (1) Soybean (1) Soybean powder (1) Strawberry (1) Sugar (1) Sweet Corn (1) Sweet potato (1) Sword bean (1) Tamarind (1) Textured soy protein (1) Tomato paste (1) Vanilla bean (1) Vanilla bean seeds (1) Vanilla paste (1) Vanilla puree (1) Water chestnut (1) Watermelon (1) Wine (1) Winter squash (1) Xylitol (1) Xylitol Syrup (1)
Produced location	China (31) Italy (30) South Africa (19) Philippines (18) United States of America (16) Turkey (13) Mexico (12) Russian Federation (6) Brazil (5) Malta (5) Australia (4) Malaysia (4) Netherlands (4) Spain (4) Taiwan (4) Dominican Republic (3) India (3) Cameroon (2) Costa Rica (2) Germany (2) Canada (1) Chile (1) Hungary (1) Ireland (1) Japan (1) Kazakhstan (1) Moldova (1) Pakistan (1) Portugal (1) Thailand (1) United Kingdom of Great Britain and Northern Ireland (1) No Location (0)
Distributed location	No location (141) Italy (32) Germany (19) Netherlands (18) Spain (18) France (17) Austria (15) Belgium (15) Hungary (15) Switzerland (15) United States of America (6) United Kingdom of Great Britain and Northern Ireland (5) Worldwide (3) Canada (2) Serbia (2) Chile (1) China (1) Ireland (1) Japan (1) Kuwait (1) Norway (1) Sweden (1) Turkey (1)

Table 3.2 *Records on fraud incidents with organic potatoes, carrots, and onions in the Decernis food fraud database (2004-June 2021).*

Product	Adulterant	Type of fraud	Year began	Year reported	Produced location	Distributed location
Organic potato	Non-organic potato	Fraudulent labelling claims	2007	2010	Italy	Hungary, Switzerland, Spain, Austria, Italy, Netherlands, France, Belgium, Germany
Organic potato	Non-organic potato	Fraudulent labelling claims		2011	China	Unknown
Organic carrot	Non-organic carrot	Fraudulent labelling claims		2011	China	Unknown
Organic onion	Non-organic onion	Fraudulent labelling claims		2011	China	Unknown
Organic onion	Non-organic onion	Fraudulent labelling claims		2014	Turkey	Unknown

3.2 Bird's eye view fraud vulnerability assessments

The organic potatoes', carrots', and onions' supply chains were subjected to the bird's eye view fraud vulnerability assessments. The results are listed in Table 3.3. The vulnerability level assignment (1-3) with justification is available in Annex 4.

Table 3.3 *Results of the bird's eye view fraud vulnerability assessment of organic potatoes', carrots', and onions' supply chains in comparison with results for organic bananas', olive oil, eggs', and pork chains which were converted from empirical data from a previous study [4]. NA = Not applicable.*

Question number	Indicator	Organic potatoes	Organic carrots	Organic onions	Organic bananas	Organic olive oil	Organic eggs	Organic pork
1	Ease of adulteration	2	2	2	1	2	1	3
2	Availability of knowledge and technology	3	3	3	2	3	2	1
3	Level of detectability	2	2	2	2	2	2	3
4	Ease of counterfeiting	NA	NA	NA	NA	NA	NA	NA
5	Ease of access in companies	2	2	2	1	2	1	2
6	Supply chain characteristics	1	1	1	1	1	2	1
7	Historical evidence	1	1	1	2	2	2	2
8	Supply and pricing	3	2	1	1	2	1	1
9	Price differences	1	1	1	2	2	3	2
10	Value-adding properties	3	3	3	2	3	3	2
11	Economic health	1	1	1	1	1	1	1
12	Business strategy	1	1	1	1	2	2	1
13	Financial strains	2	2	2	1	1	2	1
14	Level of competition	1	1	1	3	3	3	2
15	Ethical business culture	1	1	1	1	2	2	1
16	Corruption level	1	1	1	2	2	2	1
17	Criminal offences	1	1	1	2	2	3	3
18	Level of fraud monitoring systems	1	1	1	2	3	2	1
19	Level of verification of fraud monitoring systems	1	1	1	2	2	2	2
20	Level of information systems	2	2	2	3	2	3	2
21	Level of tracking & tracing systems	2	2	2	2	2	3	2
22	Contingency measures	3	3	3	2	2	3	3
23	Level of integrity screening	3	3	3	2	2	2	3
24	Level of ethical codes of conduct	3	3	3	2	2	2	3
25	Level of whistle blowing systems	3	3	3	2	2	2	3
26	Level of contractual requirements	2	2	2	2	2	1	3
27	Level of social control and transparency	1	1	1	2	2	2	2
28	Level of fraud guidance	1	1	1	2	2	2	2
29	Level of food policy considering food fraud	3	3	3	2	3	2	2
30	Level of enforcement	2	2	2	2	2	2	2
Total score	Opportunities (Question 1-7: max 21)	11	11	11	9	12	10	12
	Motivations (Question 8-17; max 30)	15	14	13	16	20	22	15
	Controls (Question 18-30; max 39)	27	27	27	27	28	28	30

The cumulated vulnerability results for the opportunities, motivations, and controls reveal a similar level of vulnerability for the organic potatoes', organic carrots', and organic onions' chains. The vulnerabilities from opportunities are also like those of the formerly assessed organic bananas', olive oil, eggs' and organic pork chains. On the contrary, motivational drivers in the organic potatoes', carrots', and onions' chains are considerably lower than those in the organic olive oil and organic eggs' chains. Regarding vulnerabilities due to lack of adequate controls in the organic potatoes', carrots, and onions' chains are like those of the organic bananas', olive oil, and eggs' chains but lower than those in the organic pork chain. Altogether, the organic chains appear to have a lot in common in respect to their fraud vulnerabilities. The newly assessed organic potatoes', carrots', and onions' chains appear to be comparably vulnerable to the organic bananas chain. The three chains appear in general less vulnerable than the organic olive oil, eggs', and pork chains.

3.3 Social network analysis

3.3.1 Results of the questionnaire

Due to the similar level of fraud vulnerability and the comparable perception of ease to commit fraud and occurrence of fraud in the organic potatoes', carrots', and onions' chains, the social network analysis was focused on the economically most important chain: The organic potatoes' chain.

3.3.1.1 Contacts between actor groups

The contacts between the actor groups are qualitatively described in an affiliation matrix in Table 3.4. In addition to the given (stated) actors, the participants also had the opportunity to mention other actors they are in contact with. Actors that were mentioned are suppliers of seed potatoes, advisors, retailers/salespoints other than a supermarket, and branch organisations such as BioNext and Skal. The frequency the actors were mentioned by the assessed actors is listed in Table 3.5. Potato growers interact primarily with other potato growers and wholesalers along the chain, and half of them also with packaging companies. Some also reported contact with potato breeders and other retailers than supermarkets. Wholesalers and supermarkets (corporate level) indicate that they interact more broadly, i.e., are in contact with actors from (nearly) all nodes in the chain.

For the intensity of contact between the participants and the various pre-stated actors, the means were first considered. The means and the standard deviations are shown in Table 3.6. Values closer to 1 indicate no or few contacts and those closer to 4 more extensive contacts. The potato growers have generally less intensive contacts with actors along the chain, including other potato growers according to their own perception. On the contrary, wholesalers reported not only most interactions with other nodes (see above), but also most extensive contacts with other parties along the chain. They appear important 'spiders in the web'. For the type of the activities that took place between the various actors, the following were mentioned: exchange of knowledge, exchange of goods, consultation, and exchange of financial resources. The frequency each of these activities was mentioned per actor group is shown in Table 3.7. In the early stages of the chain, the activities involve primarily exchange of knowledge and goods, whereas towards the wholesalers and supermarkets the activities evolve towards exchange of goods and consultation.

Table 3.4 *Affiliation matrix of actor group interactions in the organic potato supply chain: Number of interviewees (and proportion of group in brackets) that indicated contacts with the specific actor group[*].*

		Contact actor group				
Assessed actor group	**Interviewees (#)**	**Potato grower**	**Packaging company**	**Wholesaler**	**Supermarket**	**Other actor group**
Potato grower	35	31 (89%)	16 (47%)	27 (77%)	8 (23%)	12 (34%)
Packaging company**	1	1	1	1	0	0
Wholesaler	4	4 (100%)	4 (100%)	4 (100%)	4 (100%)	2 (50%)
Supermarket	4	3 (75%)	3 (75%)	3 (75%)	4 (100%)	1 (25%)
Other actor group	8	8 (100%)	2 (25%)	7 (88%)	2 (25%)	2 (25%)

* Actor groups in rows are those that filled out the survey, actors that are their contacts are listed in columns.

** Only one participant in this category completed the survey.

Table 3.5 *Frequency of additional actor groups mentioned as contacts by the actors who filled out the survey (number of actors mentioning a particular additional actor group)[*].*

	Contact actor group			
Assessed actor group	**Suppliers of seed potatoes**	**Advisors**	**Retailers/salespoints other than a supermarket**	**Organisations such as Bionext and Skal**
Potato grower	5	4	7	
Packaging company				
Wholesaler	1		1	1
Supermarket				1
Salespoint other than a supermarket			2	

[*] Actors in rows were those that filled out the survey, actors that are their contacts are listed in columns.

Table 3.6 *Means ± Standard Deviation for the intensity of contacts between actor groups[*].*

	Contact actor group			
Assessed actor group	**Potato grower**	**Packaging company**	**Wholesaler**	**Supermarket**
Potato grower	2.80 ± 0.80	1.77 ± 0.97	2.14 ± 0.81	1.29 ± 0.57
Packaging company**	4.00	2.00	2.00	1.00
Wholesaler	3.75 ± 0.50	3.75 ± 0.50	3.75 ± 0.50	3.00 ± 1.16
Supermarket	2.25 ± 1.26	2.75 ± 1.26	3.00 ± 1.41	4.00 ± 0.00

* Actors in rows are those that filled out the survey, actors that are their contacts are listed in columns; for explanation of score assignment for intensity of contacts see Annex 2.

**Only one participant in this category completed the survey.

Table 3.7 *Frequency of the mentioned type of interactions/activities per actor group.*

Contact actor group	Assessed actor group: potato grower			
	Exchange of knowledge	**Exchange of goods**	**Consultation**	**Exchange of financial resources**
Potato grower	17	9		
Packaging company				
Wholesaler	2			
Supermarket	2	1		
Salespoint other than a supermarket		4		
Contact actor group	**Assessed actor group: Packaging company**			
	Exchange of knowledge	**Exchange of goods**	**Consultation**	**Exchange of financial resources**
Potato grower	3	7	7	1
Packaging company				
Wholesaler			1	
Supermarket	1	1	3	
Salespoint other than a supermarket				
Contact actor group	**Assessed actor group: Wholesaler**			
	Exchange of knowledge	**Exchange of goods**	**Consultation**	**Exchange of financial resources**
Potato grower	2	9	5	
Packaging company				
Wholesaler			2	
Supermarket		1	1	
Salespoint other than a supermarket		3		
Contact actor group	**Assessed actor group: Supermarket**			
	Exchange of knowledge	**Exchange of goods**	**Consultation**	**Exchange of financial resources**
Potato grower		4	1	
Packaging company				
Wholesaler			1	
Supermarket		1	1	
Salespoint other than a supermarket				

3.3.1.2 Ease of fraud commitment and fraud occurrence

The ease of committing fraud in organic potatoes scored 61 ± 28 (scale: 0 is extremely easy and 100 is extremely difficult) according to the data provided by the participants. Hence, committing fraud is perceived as somewhat difficult. A one-way ANOVA was applied to test for differences in opinion between actor groups. No significant differences between actor groups were observed, $F(4,39) = 0.846$, $p = 0.505$.

The question on the occurrence of food fraud in the organic potato supply chain in the Netherlands received a score of 78 ± 27 by the participants (scale: 0 is very often and 100 is never) which shows that actors had the impression that fraud with organic potatoes is not very common. A one-way ANOVA was applied to test for differences in opinion between actor groups. No significant differences between actor groups were observed, $F(4,39) = 0.250$, $p = 0.908$.

3.3.2 Social network map

With one glance at the visualised social network, one could identify who does business with whom and which entities act as bridges between two clusters, and gain insight into the overall structure of the networks (i.e. to what extent are entities connected). Therefore, the results of the social network analysis are summarised in a simplified structure in Figure 3.2. A more detailed map is provided in Figure 3.3. Many growers have contacts with growers, wholesalers, and packaging companies. Fewer have contact with retailers. Moreover,

breeders, branch organisations, and advisors are connected the least. The network map also reveals that some actors interact more than others. To examine these differences in greater detail, an MCA was carried out. The MCA plot is presented in Figure 3.4. The plot reveals three main groups of actors. Group A is a group of actors that has frequent contacts with (other) growers, but not with other types of actors. This group comprises 18 of the 35 growers, none of the wholesalers, retailers or packaging companies, and five out of the seven other actors. Hence, it is primarily an organic potato growers' group that has contacts among themselves, but with few other actor groups/nodes in the chain. We could consider this the 'Contacts within the potato growers node group'. Group B comprises a group of actors which is not much in contact with growers, but does have frequent contacts with wholesalers, packaging companies, and retailers (supermarkets). This group comprises 12 potato growers, three of the four wholesalers, all retailers, the packaging company, and two other actors. This could then be considered the 'Contacts across supply chain nodes group'. Finally, Group C consists of five growers and one wholesaler who have hardly any contact with other growers but do have contacts with external organisations outside the direct chain, such as breeders, advisors, and the branch organisations. This group can be considered the 'Contacts outside the chain group'. Hence, three distinctive groups were identified.

The frequency of contacts with other actors varies too. Some actors indicated very intensive contacts with retailers, wholesalers, growers, and packaging companies, e.g., Growers G6 and G11, wholesaler W2, retailers R1 and R4, and other actors O3, O7, and O8. The others indicated moderate or low-level intensity of their contacts with actors within their own group and other groups. What is interesting is that the more connected group perceived it as easier to commit fraud (score = 51) than the actors in the less connected group (score = 63) (scale: 0 is extremely easy and 100 is extremely difficult). On the other hand, they rated the occurrence of food fraud in the chain lower (score = 87) than the others (score = 76) (scale: 0 is very often and 100 is never).

Knowledge on who is very well connected and having frequent and intensive contacts is important, since this knowledge can be used to evaluate or predict the possible influence of these actors in food fraud networks if fraud risk or vulnerability status is available. One of the core assumptions of social network analysis is that the structure of the connections influences individual and organisational behaviour. The relationships between actors might enable or restrain access to resources, exchange of information, or lead to exposure to social norms and culture. Those that are well-connected are in this respect more influential than others. This knowledge can also be used for mitigation measures, if needed, i.e., to estimate the consequences of de-activating or removing specific actors from the networks to destabilise the (criminalised) networks.

Figure 3.2 *Simplified social network map of the organic potato supply chain.*

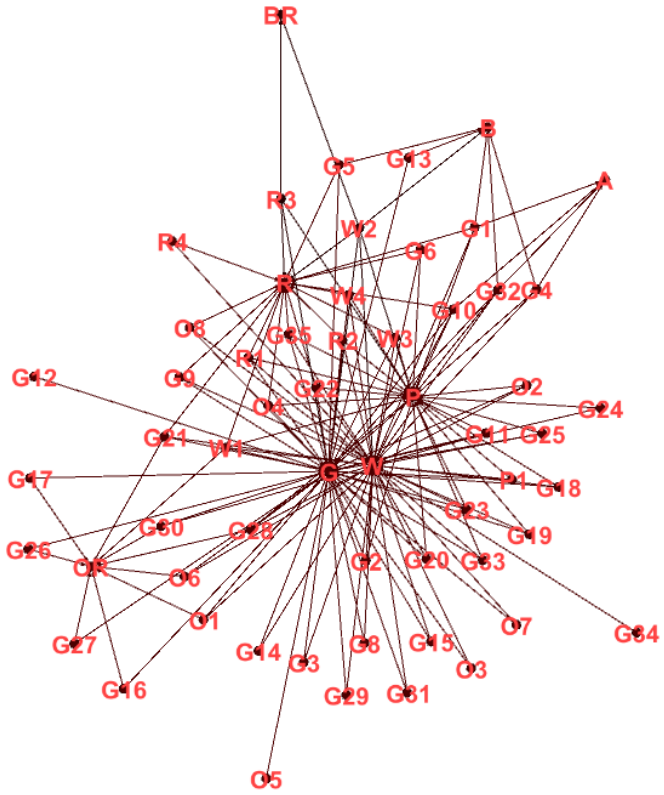

Figure 3.3 *Social network map with all assessed actors and their contacts. A=Advisor, B=Branch organisation, BR=Breeder, G=grower, OR=Other retail, P=Packaging company, R=Retailer (supermarket), W=Wholesaler.*

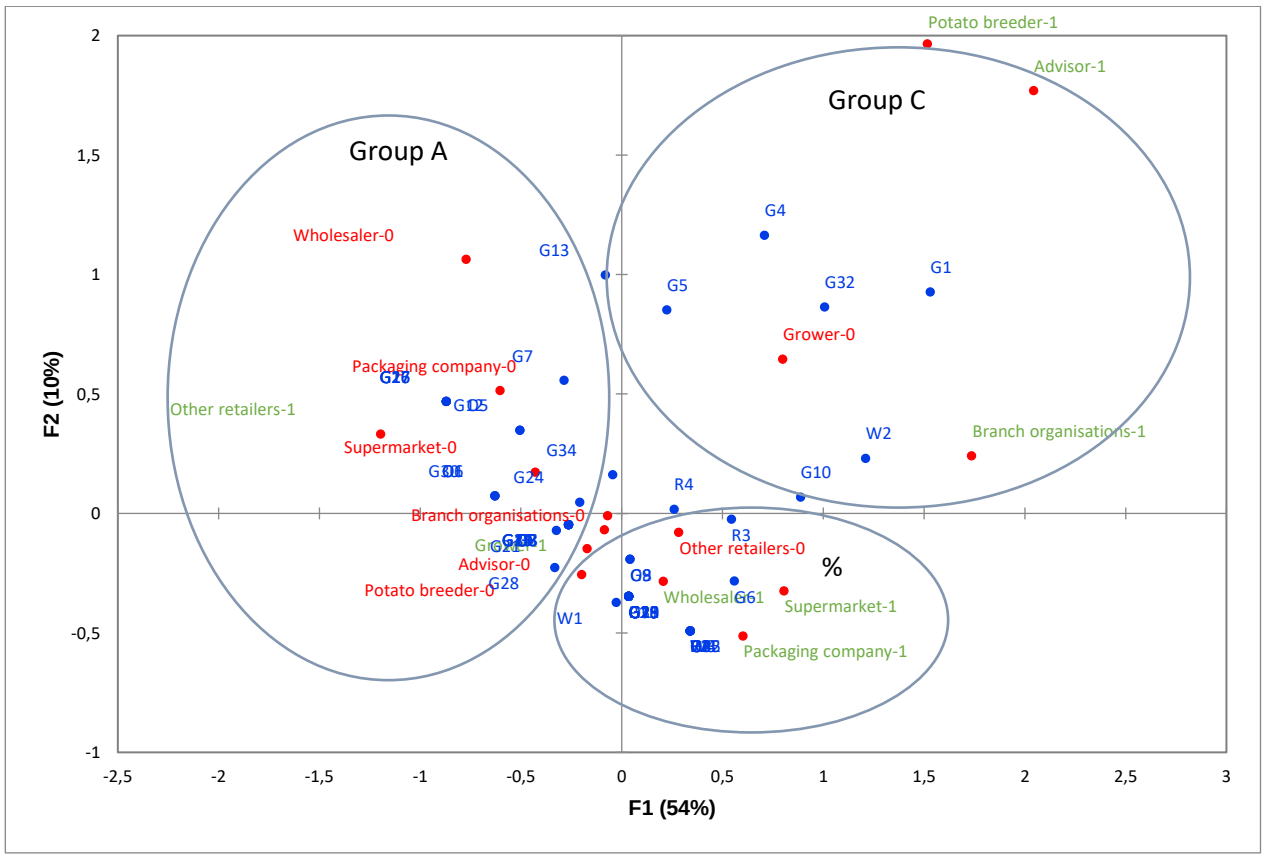

Figure 3.4 *First two dimensions of a Multiple Correspondence Analysis plot on the social network data. In red: Actor groups with whom the assessed actors are not in contact with; in green: Actor groups with whom the assessed actors are in contact with; in blue: assessed actors; G=Grower, O=Other actor group, P=Packaging company, R=Retailer (supermarket), W=Wholesaler.*

4 Conclusions

- Most of the 201 fraud-related incidents of organic food fraud were listed for plant-based food products in the Decernis food fraud database (2004-2021). They included fruits (42), cereals and pulses (38), spices/herbs/flavourings (20), vegetables (19), processed food products (14: juice, oil, jam, infant food, tomato paste, wine, etc.), seeds (13), and coconut products (12). Only five incidents were reported for organic potatoes (2), carrots (1), and onions (2).
- Forty-seven out of the 201 food fraud incidents associated with organic foods listed in the Decernis food fraud database carried a food safety risk.
- The level of fraud vulnerability is rather low and at a similar level for the organic potatoes', organic carrots', and organic onions' chains.
- The organic potatoes', carrots', and onions' chains are comparably vulnerable to fraud as the organic bananas chain but appear less vulnerable than the organic olive oil, eggs', and pork chains.
- Supply chain actors report few occurrences of food fraud in the three chains.
- Social network analysis revealed three distinctive groups among the actors in the organic potato supply chain: (A) a group with primarily intensive contacts within the potato growers' group, (B) a group with many contacts across all the organic potato supply chain nodes, and (C) a group with mainly contacts outside the chain. Some actors appear to be 'spiders' in the social web.

To conclude: The 'hotchpotch' supply chains present few fraud incidents and national fraud occurrence is low, according to the perception of Dutch chain actors. Moreover, assessments showed that the Dutch chains present few food fraud vulnerabilities. Social network analysis revealed a distinctive social structure in the organic potatoes' supply chain. Although in the current situation food fraud risks are low, further application of the approach will strengthen the toolbox to comprehend, mitigate and combat food fraud in future studies.

5 Recommendations

- Currently little is known about social networks in a food fraud context in general. It is recommended to broaden this knowledge and to examine other supply chains as well, and especially those with frequent food fraud incidents (meat, dairy, honey, spices, fats and oils, e-commerce, etc.).
- Further investigation is recommended into the causes behind the higher food fraud incident listings of organic plant-based products compared to animal-based products in the light of the reversed order for these products from conventional production systems in international food fraud incident rankings.

6 Acknowledgements

Authors gratefully acknowledge SKAL Biocontrole and organic food business operators for providing insights into supply chain characteristics, daily practices, and their business-related social networks.

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Annex 1 Bird's eye view food fraud vulnerability assessment: Questions and situations reflecting vulnerability levels

Note: Opportunities-related questions are coloured light red, motivations-related questions darker red, and controls-related questions are coloured green. For opportunities answer option 1 to 3 reflect low to high vulnerability level, for controls the order is reversed.

Question number	Question	Answer option 1	Answer option 2	Answer option 3
1	Is it simple or complex to adulterate materials in the chain/sector?	• Composition of the materials cannot be modified, and products can only be replaced, i.e., it concerns large objects such as fruit	• Composition of the raw materials can be modified by mixing with low-quality product-own material or foreign material, i.e., as is feasible with ground products (e.g., powders, ground beef, etc.)	• Composition of the raw materials can be modified by mixing with low-quality or foreign material (e.g., powders, ground meat, etc.) and by altering valuable food components (e.g., protein content)
2	Is the technology and knowledge to adulterate generally available in the chain/sector?	• Technologies and/or methods to adulterate the raw materials are neither available, known, or reported	• Advanced technologies, methods, facilities and/or knowledge are required to adulterate the raw materials	• Simple/basic technologies and methods are available, and no specialist facilities are required, to adulterate the raw materials • The knowledge required for adulteration is generally available
3	How easily would adulteration in general be detected and what kind of methods are available?	• Detection of adulteration of final products is easy and performed with common/simple methods (e.g., visual inspection, smelling)	• Established on-site methods are available for fraud screening (e.g., test kits) but confirmation of adulteration requires additional testing	• Detection and confirmation of adulteration of final products requires advanced laboratory analyses, or testing for adulteration is not available at all
4	Is brand counterfeiting an issue in this chain/sector?	• Brand counterfeiting does not apply, or it is complex to counterfeit the product and technologies, methods, facilities, and knowledge are not generally available	• Products can be counterfeited but this requires advanced technologies, methods, facilities and/or knowledge	• Products can easily be counterfeited, and technologies, methods, facilities and knowledge are generally available
5	How would you describe the production lines / processing activities in companies in this chain/sector?	• Production lines and processing activities are characterized by continuous flow processes and minor equipment modifications between batches, with only authorized personnel access both day and night	• Production lines and processing activities are characterized by large batches with minor equipment modifications between batches (repetitive flow), with the opportunity for unauthorized access to equipment but no night processing	• Production lines and processing activities are characterized by relatively small batches with major modifications between batches (intermittent flow), and the opportunity for unauthorized access both during day and night

Question number	Question	Answer option 1	Answer option 2	Answer option 3
6	How would you describe the food supply chain?	• The supply chain is transparent, with good insight into suppliers and customers	• The supply chain is not fully transparent; only direct suppliers and customer are known	• The supply chain is complex and lacks transparency; typically, customers and suppliers are geographically disbursed
		• Business relationships are long-term relationships and characterized by trust	• Business relationships are variable; some relationships are long-term, others short-term	• Business relationships are ad-hoc and price is the main driver for selecting suppliers
		• The supply chain is integrated, well-coordinated, with comprehensive information exchange across the supply chain	• Some degree of integration exists across the supply chain; information exchange occurs mainly with direct suppliers and customers	• No information exchange occurs between direct suppliers and customers
7	Have fraudulent incidents of similar materials used and produced in this chain/sector been reported in the past?	• No fraudulent incidents related to raw materials are known	• A few fraudulent incidents have occurred with specific raw materials	• Many fraudulent incidents have occurred with specific raw materials
		• No documented evidence/information of fraud is available	• Limited documentation and few/no media reports are available	• Incidents are well known and documented, and have received substantial media attention
8	How would you define the supply and pricing in the chain?	• Raw materials are readily available	• Stable prices but the supply of raw materials is not readily available	• Tight global supplies of raw materials and/or shortages exist
		• No export bans on raw materials exist		• Export bans on raw materials exist in many countries
		• Prices for raw materials are stable	• Export bans on raw materials exist in a few countries	• Price spikes of raw materials are common
		• Pricing of raw materials is independent of geographical origin		• Large differences in prices of materials from different geographical regions
		• Prices of substitute raw materials are equivalent		• Prices of substitute raw materials vary greatly
9	Are there price differences as a result of regulatory differences across countries in this chain?	• The price policy of food ingredients and food products is similar for all countries	• The price policy of food ingredients and food products is different in some countries	• The price policy of food ingredients and food products varies considerably across different countries
10	Do special attributes or components determine the value of products in this chain?	• The value of raw materials is not determined by its composition, way of production or origin	• The value of raw materials is influenced by its composition (e.g., protein or fat content)	• Value of raw materials is greatly determined by its composition, way of production and/or origin
11	How would you describe the economic health of companies in this chain?	• The market is profitable, and companies achieve their financial targets	• Profits are declining, and there is a gap between financial targets and actual performance in many businesses	• There are financial losses, and it is difficult to meet financial targets in many businesses
12	What are generally the characteristics of the business strategy of companies in this chain?	• Long term financial targets, coupled with food quality and safety goals, and how the objectives should be achieved, are well specified	• Financial targets and food quality and safety goals are ambiguous • There's a lack of clarity about the means to achieve these objectives	• There is a strong emphasis to achieve (short-term) financial goals, while the means to achieve them legitimately is generally not specified

Question number	Question	Answer option 1	Answer option 2	Answer option 3
13	How would you describe the financial strains imposed by companies in this chain/sector?	• The companies set fixed prices for direct supplier(s) in line with market prices, and supplier(s) have other customers	• The companies typically buy from suppliers that offer the lowest price and suppliers are somewhat dependent on the companies for their financial survival	• The companies generally buy from suppliers that offer the lowest prices and suppliers are completely dependent on the company for their financial survival
14	How would you rate the level of competition across the supply chain?	• Low levels of competition across the supply chain	• Medium levels of competition across the supply chain	• Fierce competition across the supply chain
15	How would you describe the ethical business culture across the supply chain?	• Ethical business culture is characterized by a high level of mutual trust and respect; ethical discussions and ethical conduct is highly valued between companies	• Ethical business culture is characterized by overall mutual trust, limited and ad hoc ethical discussions and ethical conduct is moderately valued between companies	• Ethical business culture is characterized by lack of mutual trust & interests, restricted/no moral/ethical discussions and ethical conduct is not valued between companies
16	How would you rate the corruption level (according to the Transparency International Corruption Perception Index) in the countries of the supply chain?	• Activities in countries with low levels of corruption (rated 76-100 on the Index)	• Activities in countries with medium levels of corruption (rated 26-75 on the Index)	• Activities in countries with high levels of corruption (rated 1-25 on the Index)
17	How common are criminal offences across the supply chain?	• There is no evidence of fraudulent activity or other forms of law breaking in this supply chain	• There may have been incidences of fraud across the supply chain but there is no specific information available	• There is well-known and documented evidence of fraudulent activity across the supply chain
18	How elaborate are the fraud monitoring systems in this chain?	• Sampling plan only for safety and quality analyses but not for fraud check	• No systematic ad-hoc sampling for fraud analysis	• Systematic, evidence-based (using both historical and scientific data) sampling plan for fraud-related analyses
		• No methods for fraud detection in place; external fraud analysis only in case of inspection demands/fraud issues	• General screening (quick) methods in place but no (external) confirmatory fraud testing	• Specific fraud screening methods and systematic use of fit-for-purpose confirmatory techniques (in house or in collaboration with accredited laboratories)
		• No procedures for fraud monitoring tasks	• General procedure for sampling and screening for monitoring of ingredient/raw material fraud issues	• Customized procedures for fraud monitoring and handling of non-conformities
		• No record keeping on adulterated or suspicious raw materials, and no documentation of fraud procedures	• Record-keeping in case of deviations; limited documentation on fraud monitoring procedures/systems	• Systematic record keeping and detailed documentation of fraud monitoring procedures & systems

Question number	Question	Answer option 1	Answer option 2	Answer option 3
19	Are the fraud monitoring tasks of control systems in this chain/sector well verified?	• No verification of fraud monitoring tasks	• Ad-hoc and or announced verification of fraud monitoring tasks; mainly based on analysis of records and check of presence of procedures (e.g., as part of auditing)	• Systematic and comprehensive verification (document & record analysis, observations, and actual testing), unannounced and performed by autonomous controller of fraud monitoring tasks
			• Ad-hoc reporting of verification outcomes; mainly in case of deviations	• Systematic documentation of verification activities and outcomes
20	How extensive are the information systems for internal control of mass balance flows in this chain?	• Basic administrative systems with limited information or no specific information on mass balances of incoming materials and final products	• Process monitoring information system with accurate information on mass balances of mainly bulk ingredients	• Established and comprehensive (accurate mass balance data, of all crucial ingredients, materials, & final product flows) process monitoring information system dedicated for control of mass balance flows
		• Data only analysed in case of inspection requirements	• No integral analysis of mass flow data throughout the companies	• Structured record keeping of mass flow information and systematic analysis of integral data of the companies
21	How extensive are the tracking & tracing system in this chain?	• Traceability systems without clearly defined traceability resource units or units cannot be exactly defined (e.g. because of continuous flow).	• Systems with clearly defined traceability resource units; Collection of accurate information but not specifically addressing fraud issues, only information on company level	• Systems with clearly defined traceability resource units (product level; collection of accurate information including fraud-relevant issues from direct supplier up to direct customer
		• Uncertainty about accuracy of information, and limited/no fraud relevant information	• Computer-based data capturing & retrieval system but not systematically controlled (restricted possibilities for fraud)	• Advanced automated and systematically controlled robust data capturing and data retrieval system (fraud proof)
		• Data capturing and retrieval system is not fraud proof		
22	Do companies in the chain/sector generally have fraud contingency measures in place?	• No documented risk/contingency plans for fraud issues are generally in place	• Documented risk/contingency plans are in place with communication principles and tools for safety issues and recalls, but fraud issues not explicitly addressed	• Integrated risk/contingency plan for both fraud and safety issues is in place, with detailed communication principles and tools that are well documented and updated regularly
23	How common is integrity screening of employees in this chain?	• •o integrity screening of employees	• Use of established integrity screening methods for employees at key positions	• Use of established integrity screening methods is standard for employment of all personnel

Question number	Question	Answer option 1	Answer option 2	Answer option 3
24	How common are ethical codes of conduct or guidelines in place and embedded in this chain/sector?	• No written code of ethical conduct or guideline exist	• General written code of ethical conduct or guidelines is available, but awareness amongst all personnel is limited, and or code is not explicitly embedded in management activities	• Detailed written code of ethical conduct or guideline is available and well embedded; awareness amongst all personnel is stimulated (e.g. posters, communication) and demonstrated in management activities
25	How common are whistle blowing systems (system for reporting assumed fraudulent activities) in place in this chain?	• No whistle blowing systems exist	• Whistle blowing systems are available, but no clear protection system for the whistle blower is in place, and reporting of fraudulent activity goes usually to supervisor (no independent officer)	• Whistle blowing system is well-established and well-known among personnel, fraudulent practices can be reported to an independent officer, and anonymity of the whistle blower is strictly protected
26	Do contractual requirements with suppliers include elements that limit opportunities for fraud in this chain in general?	• Contractual requirements for direct suppliers are mainly set on logistic parameters: cost, amount, and availability	• Contractual requirements are established together with direct supplier(s) for both logistic and safety & quality parameters	• Comprehensive contractual requirements established in close collaboration with direct supplier(s) addressing logistics, safety, and quality, but also requirements on adoption of ethical code/guidelines, and adoption of similar technical fraud control measures
27	How would you describe the social control and transparency of actions across the chain/sector?	• No self-regulation and poor communication between companies across the supply chain	• The supply chain has a certain degree of self-regulation but communication depends on individual companies (i.e. not systematic)	• The supply chain self-regulates and communication between companies is very active
		• Limited/no self-regulating tools (e.g., code of conduct, certification scheme) exist, limited/no monitoring on compliance	• Self-regulating tools (e.g., code of conduct, certification scheme) exist but are not widely implemented and compliance is not monitored systematically	• Self-regulating tools (e.g. code of conduct, certification scheme) are widely implemented and compliance is monitored systematically
		• Unethical conduct is rarely communicated	• Only serious/obvious unethical conduct and/or incident are communicated	• All unethical conduct is systematically communicated across the supply chain and information is widely shared
28	How well established is guidance for fraud prevention and control across the chain/sector?	• No specific guidelines for fraud mitigation exist or are not shared; guidelines focus on safety only	• General guidelines (mainly via websites) for fraud mitigation measures are available, but there are no examples of best practices of mitigation measures	• Specific guidelines and examples of best practices for fraud monitoring & mitigation are provided actively via website, training, information brochures and other mediums

Question number	Question	Answer option 1	Answer option 2	Answer option 3
29	How well covers food policy food fraud along the chain?	• Only a general food policy exists without specific legislative requirements for food fraud mitigation	• Food policy with generally defined legislation for food fraud mitigation but it is not harmonized with internationally recognized recommendations for food fraud mitigation	• Well established food policy with detailed specifically defined legislation to mitigate against food fraud that is harmonized with internationally recognized recommendations for food fraud mitigation
30	How well are fraud related laws enforced across the chain?	• Fraud related enforcement practices are lacking at most stages across the supply chain	• Fraud related enforcement practices exist across parts of the supply chain but the frequency of inspections by regulatory/law enforcement agencies varies	• Fraud related enforcement practices are aligned across all stages of the supply chain with risk-based frequency of inspections by regulatory/law enforcement agencies
		• Little or no fines/sanctions and the financial impact is minimal	• Fines/sanctions vary considerably across the supply chain	• High level of fines/sanctions with substantial financial impact

Annex 2 Social network questionnaire (in Dutch)

Beste deelnemer. Bedankt dat u de tijd en moeite wil nemen om mij te helpen met mijn masterscriptie. Ik ben Linsey en ik studeer Food Quality Management aan de Universiteit van Wageningen. Voor mijn scriptie probeer ik het netwerk van de biologische aardappel te begrijpen en ben daarom op zoek naar mensen die werken in de productieketen van de biologische aardappel. Als u niet werkt in de biologische aardappel productieketen verzoek ik u om de survey niet in te vullen.

In deze survey zijn geen goede en foute antwoorden. Ik ben alleen geïnteresseerd in uw mening en expertise. Het invullen van deze survey zal ongeveer 5-10 minuten duren. Daarnaast is het invullen ervan geheel vrijwillig en kunt u op elk gewenst moment stoppen. Uw antwoorden zullen anoniem verwerkt worden en zullen uitsluitend gebruikt worden voor het onderzoek.

Door op 'ja ik ga akkoord' te klikken bevestigt u dat u bovenstaande heeft gelezen en akkoord gaat met het anoniem verwerken van uw antwoorden.

- Ja ik ga akkoord
- Nee ik ga niet akkoord ☐ end of survey. Bedankt voor het starten van de survey. Helaas voldoet u niet aan de voorwaarden om deel te nemen.

Werkt u met biologische aardappelen?
- Ja
- Nee ☐ end of survey. Bedankt voor het starten van de survey. Helaas voldoet u niet aan de voorwaarden om deel te nemen.

In wat voor soort bedrijf werkt u?
- Op een boerderij
- In een verpakkingsbedrijf
- Bij een groothandel
- Bij een supermarkt
- Anders, namelijk…

Om een duidelijke schets te maken wie er met wie contact heeft in de productieketen van de biologische aardappel vraag ik u om aan te geven met welk bedrijf u in het kader van uw werk contact heeft.

Aardappeltelers
- Ik heb geen contact met aardappeltelers in het kader van mijn werk (score = 1)
- Ik heb weinig contact met aardappeltelers in het kader van mijn werk (score = 2)
- Ik heb regelmatig contact met aardappeltelers in het kader van mijn werk (score = 3)
- Ik heb vaak contact met aardappeltelers in het kader van mijn werk (score = 4)

Biologisch verpakkingsbedrijf
- Ik heb geen contact met biologische verpakkingsbedrijven in het kader van mijn werk (score = 1)
- Ik heb weinig contact met biologische verpakkingsbedrijven in het kader van mijn werk (score = 2)
- Ik heb regelmatig contact met biologische verpakkingsbedrijven in het kader van mijn werk (score = 3)
- Ik heb vaak contact met biologische verpakkingsbedrijven in het kader van mijn werk (score = 4)

Groothandel
- Ik heb geen contact met groothandelaren in het kader van mijn werk (score = 1)
- Ik heb weinig contact met groothandelaren in het kader van mijn werk (score = 2)
- Ik heb regelmatig contact met groothandelaren in het kader van mijn werk (score = 3)
- Ik heb vaak contact met groothandelaren in het kader van mijn werk (score = 4)

Supermarkt
- Ik heb geen contact met supermarkten in het kader van mijn werk (score = 1)
- Ik heb weinig contact met supermarkten in het kader van mijn werk (score =2)
- Ik heb regelmatig contact met supermarkten in het kader van mijn werk (score =3)
- Ik heb vaak contact met supermarkten in het kader van mijn werk (score =4)

Wat voor soort activiteiten vinden er plaats tussen u en het aangegeven bedrijf? Denk bijvoorbeeld aan het uitwisselen van informatie, producten of financiële middelen.
De activiteiten die plaatsvinden tussen mij en een biologische aardappelteler zijn: …
De activiteiten die plaatsvinden tussen mij en een biologisch verpakkingsbedrijf zijn: …
De activiteiten die plaatsvinden tussen mij en een groothandel die biologische aardappelen verkoopt zijn: …
De activiteiten die plaatsvinden tussen mij en een supermarkt die biologische aardappelen verkoopt zijn: …

Zijn er nog andere bedrijven waar u vaak contact mee heeft in het kader van uw werk?
- Nee ☐ Volgende vraag overslaan
- Ja, namelijk …

Wat voor soort activiteiten vinden er plaats tussen u en het aangegeven bedrijf? …

Fraude met biologische aardappelen is bijvoorbeeld het verkopen van gangbare aardappelen als biologisch.
Hoe makkelijk/moeilijk denkt u dat het is om dit soort fraude te plegen?
☐ Lijnschaal, helemaal links zeer makkelijk en helemaal rechts zeer moeilijk

Denkt u dat fraude met biologische aardappelen veelvuldig voorkomt in Nederland?
☐ Lijnschaal, helemaal links zeer vaak en helemaal rechts nooit
Dit was het einde van de survey. Heel erg bedankt voor uw deelname.

Annex 3 Fraud incidents of organic products in the Decernis food fraud database 1980-2021

Decernis database [14]; Data retrieved June 2021.

Ingredient	Ingredient synonyms	Adulterants	Record type	Produced location	Distributed location	Incident year
Agave Inulin	Organic Agave Inulin	Agave Inulin (Non-Organic)	Incident	South Africa		2011 - 2012
Agave Inulin Powder	Organic Agave Inulin Powder	Agave Inulin Powder (Non-Organic)	Incident	South Africa		2011 - 2012
Agave Syrup	Organic Agave Syrup	Agave Syrup (Non-Organic)	Incident	South Africa		2011 - 2012
Agave Syrup	Organic Agave Syrup	Agave Syrup (Non-Organic)	Incident	South Africa		2014 - 2015
Agave Syrup Crystals	Organic Agave Syrup Crystals	Agave Syrup Crystals (Non-Organic)	Incident	South Africa		2011 - 2012
Agave Syrup Crystals	Organic Agave Syrup Crystals	Agave Syrup Crystals (Non-Organic)	Incident	South Africa		2014 - 2015
Alfalfa	Medicago sativa, Organic Alfalfa	Alfalfa (Non-Organic)	Incident	South Africa		2010
Alfalfa	Medicago sativa, Organic Alfalfa	Alfalfa (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Alfalfa Seed	Organic Alfalfa Seed	Pesticide (Unspecified),Alfalfa Seed (Non-Organic)	Incident	United States of America		2016
Almond	Organic Almond	Almond (Non-Organic)	Incident	Malaysia		2014
Almond	Organic Almond	Almond (Expired)	Incident	Taiwan		2017
Anchovies	Organic Anchovies	Anchovies (Non-Organic)	Incident	Italy	Italy	2018
Apple Juice	Organic Apple Juice	Apples (Decomposed, Not Fit For Human Consumption), Sugar, Water	Incident	Italy	Italy, Serbia	2019
Apples	Organic Apples	Apples (Non-Organic)	Incident	Moldova (the Republic of)	Netherlands	2020
Apples	Organic Apples	Apples (Non-Organic)	Incident	Turkey		2014
Apricot	Organic Apricot	Apricot (Non-Organic)	Incident	Turkey		2016
Aronia	Organic Aronia	Aronia (Non-Organic)	Incident	Russian Federation		2010
Avocado	Organic Avocado	Avocado (Non-Organic)	Incident	Mexico	Netherlands	2020
Avocado	Organic Avocado	Avocado (Non-Organic)	Incident	Mexico		2020
Bamboo Shoots	Organic Bamboo Shoots	Bamboo Shoots (Non-Organic)	Incident	China		2013
Banana	Organic Banana	Banana (Non-Organic)	Incident	Dominican Republic		2014
Barley	Hordeum vulgare L.	Barley (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010

Ingredient	Ingredient synonyms	Adulterants	Record type	Produced location	Distributed location	Incident year
Bell Pepper	Capsicum annuum, Organic Bell Pepper	Bell Pepper (Non-Organic)	Incident	China		2011
Bell Pepper	Capsicum annuum, Organic Bell Pepper	Bell Pepper (Non-Organic)	Incident	Dominican Republic		2010
Black Beans	Organic Black Beans	Black Kidney Beans (Non-Organic)	Incident	Thailand		2010
Blackberry	Organic Blackberry	Blackberry (Non-Organic)	Incident	Mexico		2020
Blueberry	Organic Blueberries	Blueberries (Non-Organic)	Incident	Russian Federation		2010
Bourbon Vanilla Extract	Organic Bourbon Vanilla Extract	Bourbon Vanilla Extract (Non-Organic)	Incident	Philippines		2007
Broccoli	Organic Brassica oleracea var. italica, Organic Broccoli	Broccoli (Non-Organic)	Incident	China		2011
Brown Sugar	Organic Brown Sugar	Brown Sugar (Expired)	Incident	Taiwan		2017
Buckwheat	Organic Buckwheat	Buckwheat (Non-Organic)	Incident	China		2010
Burdock Root	Organic Burdock Root	Burdock Root (Non-Organic)	Incident	China		2011
Carrot	Organic Carrot	Carrot (Non-Organic)	Incident	China		2011
Cashews	Organic Cashews	Cashews (Non-Organic)	Incident	Malaysia		2014
Cashews	Organic Cashews	Cashews (Expired)	Incident	Taiwan		2017
Cereal (Unspecified, Organic)	Organic Cereal (Unspecified)	Cereal (Expired)	Incident	Taiwan		2017
Cherries	Organic Cherry	Cherry (Non-Organic)	Incident	Turkey		2016
Chia Seeds	Organic Chia Seeds	Chia Seeds (Non-Organic)	Incident	Germany		2011
Chia Seeds	Organic Chia Seeds	Chia Seeds (Non-Organic)	Incident	Brazil		2013
Chia Seeds	Organic Chia Seeds	Chia Seeds (Non-Organic)	Incident	Brazil		2015
Chia Seeds	Organic Chia Seeds	Chia Seeds (Non-Organic)	Incident	United States of America		2008
Chia Seeds	Organic Chia Seeds	Chia Seeds (Non-Organic)	Incident	India		2018
Chicken (Free Range, Organic)	Organic Free Range Chicken	Chicken Meat	Incident	Canada	Canada	2015 - 2016
Chicken (Free Range, Organic)	Organic Free Range Chicken	Nitrofurans (Unspecified)	Incident	Ireland	Ireland	2004
Chili Pepper	Organic Chili Pepper	Chili Pepper (Non-Organic)	Incident	Mexico		2015
Chili Pepper	Organic Chili Pepper	Chili Pepper (Non-Organic)	Incident	China		2011
Chocolate	Organic Chocolate	Chocolate (Non-Organic)	Incident	Netherlands		2015 - 2018
Chocolate Extract	Organic Chocolate Extract, Organic Cocoa Extract	Chocolate Extract (Non-Organic)	Incident	Philippines		2007
Cocoa Powder	Organic Cocoa Powder	Cocoa Powder (Non-Organic)	Incident	South Africa		2011 - 2012
Cocoa Powder	Organic Cocoa Powder	Cocoa Powder (Non-Organic)	Incident	Cameroon		2012
Coconut	Organic Coconut	Coconut (Non-Organic)	Incident	Philippines		2013
Coconut Cream	Organic Coconut Cream	Coconut Cream (Non-Organic)	Incident	Philippines		2013
Coconut Flour	Organic Coconut Flour	Coconut Flour (Non-Organic)	Incident	Philippines		2013
Coconut Milk	Organic Coconut Milk	Coconut Milk (Non-Organic)	Incident	Philippines		2013
Coconut Milk	Organic Coconut Milk	Coconut Milk (Non-Organic)	Incident	Australia		2017
Coconut Milk (Powder, Organic)		Coconut Milk (Powder, Non-Organic)	Incident	Philippines		2013
Coconut Oil (Virgin, Organic)	Organic Virgin Coconut Oil	Coconut Oil (Virgin, Non-Organic)	Incident	Philippines		2013

Ingredient	Ingredient synonyms	Adulterants	Record type	Produced location	Distributed location	Incident year
Coconut Powder (Dessicated, Organic)	Organic Dessicated Coconut Powder	Coconut Powder (Dessicated, Non-Organic)	Incident	Philippines		2013
Coconut Powder (Dessicated, Organic)	Organic Dessicated Coconut Powder	Coconut Powder (Dessicated, Non-Organic)	Incident	India		2016
Coconut Water	Organic Coconut Water	Coconut Water (Non-Organic)	Incident	Philippines		2013
Coconut Water	Organic Coconut Water	Coconut Water (Non-Organic)	Incident	Australia		2017
Coconut Water (Sparkling, Organic)	Organic Sparkling Coconut Water	Coconut Water (Sparkling, Non-Organic)	Incident	Australia		2017
Cod	Organic Cod	Cod (Non-Organic)	Incident	Italy	Italy	2018
Coffee (Ground, Organic)	Organic Ground Coffee	Coffee (Ground, Non-Organic)	Incident	Cameroon		2012
Coffee	Organic Coffee	Coffee (Non-Organic)	Incident	Netherlands		2015 - 2018
Collagen Peptides Powder	Organic Collagen Peptides	Collagen Peptides Powder (Non-Organic)	Incident	Mexico		2020
Corn	Organic Corn	Corn (Non-Organic)	Incident	Turkey	United Kingdom of Great Britain and Northern Ireland	2020
Corn	Organic Corn	Corn (Non-Organic)	Incident	Brazil		2015
Corn	Organic Corn	Corn (Non-Organic)	Incident	United States of America		2008
Corn	Organic Corn	Corn (Non-Organic)	Incident	Turkey		2014
Corn	Organic Corn	Corn (Non-Organic)	Incident	United States of America		2010 - 2017
Corn	Organic Corn	Corn (Non-Organic)	Incident	Turkey	United States of America	2017
Corn	Organic Corn	Corn (Non-Organic)	Incident	Malta	Italy	2007 - 2013
Corn	Organic Corn	Corn (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Cranberries	Organic Cranberries	Cranberries (Non-Organic)	Incident	Russian Federation		2010
Eggs (Shell Eggs, Organic)	Organic Chicken Eggs	Shell Eggs (Conventional)	Incident	Spain		2020
Eggs (Shell Eggs, Organic)	Organic Chicken Eggs	Shell Eggs (Non-Organic)	Incident	Netherlands		2015 - 2018
Eggs (Shell Eggs, Organic)	Organic Chicken Eggs	Shell Eggs (Conventional)	Incident	Italy	Italy	2018
Eggs (Shell Eggs, Organic)	Organic Chicken Eggs	Shell Eggs (Conventional)	Incident	United Kingdom of Great Britain and Northern Ireland	United Kingdom of Great Britain and Northern Ireland	2004 - 2006
Eggs (Shell Eggs, Organic, Free Range)	Organic Free Range Chicken Eggs	Shell Eggs (Conventional)	Incident	Germany	Worldwide	2013
Essential Oils	Organic Essential Oils	Essential Oils (Non-Organic)	Incident	South Africa		2017

Ingredient	Ingredient synonyms	Adulterants	Record type	Produced location	Distributed location	Incident year
Field Beans (Unspecified, Organic)	Organic Field Beans (Unspecified)	Field Beans (Unspecified, Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Field Pea	Organic Field Pea, Pisum sativum subsp. arvense	Field Pea (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Flaxseed	Linseed, Linum usitatissimum Seed, Organic Flaxseed	Linseed (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Fruit (Dried, Organic)	Organic Dried Fruit	Fruit (Dried, Non-Organic)	Incident	Italy	Italy	2018
Fruits (Unspecified, Organic)	Organic Fruits (Unspecified)	Fruit (Unspecified, Non-Organic)	Incident	Italy	France, Germany, Italy, United Kingdom of Great Britain and Northern Ireland	2015 - 2017
Fruits (Unspecified, Organic)	Organic Fruits (Unspecified)	Fruit (Unspecified, Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Garlic	Organic Garlic	Garlic (Non-Organic)	Incident	China		2011
Ginger	Organic Ginger	Ginger (Non-Organic)	Incident	China		2011
Ginger	Organic Ginger	Ginger (Non-Organic)	Incident	Turkey		2014
Goji Berry	Organic Goji Berry	Goji Berry (Non-Organic)	Incident	China	Netherlands	2020
Goji Berry	Organic Goji Berry	Goji Berry (Non-Organic)	Incident	China		2012
Gooseberries	Organic Gooseberries	Gooseberries (Non-Organic)	Incident	Russian Federation		2010
Grain and Seed Products	Organic Grain and Seed Products	Grain and Seed Products (Non-Organic)	Incident	United States of America	United States of America	2012 - 2018
Grains (Unspecified, Organic)	Organic Grains (Unspecified)	Grains (Non-Organic, Unspecified)	Incident	Italy	Worldwide	2013
Grapes	Organic Grapes	Grapes (Non-Organic)	Incident	Spain	Spain	2020 - 2021
Grapes	Organic Grapes	Grapes (Non-Organic)	Incident	Turkey		2016
Hemp Seed	Organic Hemp Seed	Hemp Seeds (Non-Organic)	Incident	United States of America		2008
Hemp Seed	Organic Hemp Seed	Hemp Seeds (Non-Organic)	Incident	Brazil		2015
Herbs	Organic Herbs	Herbs (Non-Organic)	Incident	Italy	Italy	2018
Honeydew Melon	Organic Honeydew Melon, Organic White Melon	Honeydew Melon (Non-Organic)	Incident	China		2010

Ingredient	Ingredient synonyms	Adulterants	Record type	Produced location	Distributed location	Incident year
Infant Formula	Organic Infant Formula	Infant Formula (Non-Organic)	Incident	United States of America	United States of America	2015
Jam	Organic Jam	Apples (Decomposed, Not Fit For Human Consumption)	Incident	Italy	Italy, Serbia	2019
Leafy Greens	Organic Leafy Greens	Leafy Greens (Non-Organic)	Incident	United States of America		2020
Lemon	Organic Lemon	Lemon (Non-Organic)	Incident	Mexico		2015
Lemon Extract (Terpeneless, Organic)	Organic Terpeneless Lemon Extract	Lemon Extract (Terpeneless, Non-Organic)	Incident	Philippines		2007
Lemon Peel (Dried, Organic)	Organic Dried Lemon Peel	Lemon Peel (Dried, Non-Organic)	Incident	South Africa	Germany	2020
Lingonberries	Organic Lingonberries	Lingonberry (Non-Organic)	Incident	Russian Federation		2010
Macadamia Nut	Organic Macadamia Nut	Macadamia Nut (Non-Organic)	Incident	Malaysia		2014
Mango (Kent, Organic)	Organic Kent Mango	Mango (Kent, Non-Organic)	Incident	Mexico		2015
Mango (Tommy Atkins, Organic)	Organic Tommy Atkins Mango	Mango (Tommy Atkins, Non-Organic)	Incident	Costa Rica		2013
Mango (Tommy Atkins, Organic)	Organic Tommy Atkins Mango	Mango (Tommy Atkins, Non-Organic)	Incident	Costa Rica		2014
Mango (Tommy Atkins, Organic)	Organic Tommy Atkins Mango	Mango (Tommy Atkins, Non-Organic)	Incident	Mexico		2015
Meat	Organic Meat	Meat (Non-Organic)	Incident	Netherlands		2015 - 2018
Millet	Organic Millet (Unspecified Varietal)	Millet (Unspecified, Non-Organic)	Incident	China		2010
Millet	Organic Millet (Unspecified Varietal)	Millet (Unspecified, Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Mushroom Products	Organic Mushroom Products	Mushroom Products (Unspecified)	Incident	United States of America	United States of America	2007
Mushrooms	Organic Mushrooms	Mushrooms (Non-Organic)	Incident	China		2013
Nuts	Organic Nuts	Nuts (Non-Organic)	Incident	South Africa		2014
Oats	Avena sativa, Organic Oats	Oats (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Olive Oil (Extra Virgin, Organic)	Organic Extra Virgin Olive Oil	Olive Oil (Extra Virgin, Non Organic)	Incident	Portugal		2019
Onion	Organic Onion	Onion (Non-Organic)	Incident	China		2011
Onion	Organic Onion	Onion (Non-Organic)	Incident	Turkey		2014
Orange Extract (Terpeneless, Organic)	Organic Terpeneless Orange Extract	Orange Extract (Terpeneless, Non-Organic)	Incident	Philippines		2007
Oranges	Organic Oranges	Oranges (Non-Organic)	Incident	South Africa		2009
Oranges	Organic Oranges	Oranges (Non-Organic)	Incident	Italy	Italy	2018
Oregano	Organic Oregano	Leaves (Unspecified)	Incident	Turkey	Norway	2017
Pasta	Organic Pasta	Pasta (Non-Organic)	Incident	Italy	Italy	2018
Pawpaw	Organic Pawpaw	Pawpaw (Non-Organic)	Incident	Mexico		2015

Ingredient	Ingredient synonyms	Adulterants	Record type	Produced location	Distributed location	Incident year
Pineapple	Organic Pineapple	Pineapple (Non-Organic)	Incident	Mexico		2015
Pistachio	Organic Pistachio	Pistachio (Non-Organic, Containing Pesticide Residues)	Incident	Spain	Spain	2019 - 2020
Pistachio	Organic Pistachio	Pistachio (Non-Organic)	Incident	Malaysia		2014
Plum	Organic Plum	Plum (Non-Organic)	Incident	Turkey		2016
Pork	Organic Pork	Pork (Non-Organic)	Incident	Hungary		2018
Pork	Organic Pork	Pork	Incident	China	China	2009 - 2011
Potato	Organic Potato, Solanum tuberosum	Potato (Non-Organic)	Incident	China		2011
Potato	Organic Potato, Solanum tuberosum	Potato (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Processed Foods	Organic Processed Foods	Processed Foods (Non-Organic)	Incident	United States of America		2017
Pumpkin	Organic Pumpkin	Pumpkin (Non-Organic)	Incident	China		2011
Rapeseed	Brassica napus, Organic Rapeseed	Rapeseed (Non-Organic)	Incident	Malta	Italy	2007 - 2013
Rapeseed	Brassica napus, Organic Rapeseed	Rapeseed (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Raspberries	Organic Raspberry	Raspberries (Non-Organic, Alternate Geographic Origin)	Incident	Chile	Canada, Chile, Kuwait, Turkey, United States of America	2014 - 2016
Redcurrants	Organic Redcurrants	Red Currants (Non-Organic)	Incident	Russian Federation		2010
Rice (Basmati, Organic)	Organic Basmati Rice	Rice (Basmati, Non-Organic)	Incident	Pakistan		2017
Sardines	Organic Sardines	Sardines (Non-Organic)	Incident	Italy	Italy	2018
Sea Buckthorn	Organic Sea Buckthorn	Sea Buckthorn (Non-Organic)	Incident	China		2012
Sorghum	Organic Sorgham	Sorghum (Non-Organic)	Incident	South Africa		2010
Sorghum	Organic Sorgham	Sorghum (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Soy Protein Concentrate	Organic Soy Protein Concentrate	Soy Protein Concentrate (Non-Organic)	Incident	China		2013
Soy Protein Isolate	Organic Soy Protein Isolate	Soy Protein Isolate (Non-Organic)	Incident	China		2013
Soybean (Green, Organic)	Edamame, Organic Green Soybean	Soybean (Green, Non-Organic)	Incident	China		2011
Soybean	Glycine max, Organic Soybean	Soybean (Non-Organic)	Incident	China		2010
Soybean	Glycine max, Organic Soybean	Soybean (Non-Organic)	Incident	South Africa		2010

Ingredient	Ingredient synonyms	Adulterants	Record type	Produced location	Distributed location	Incident year
Soybean	Glycine max, Organic Soybean	Soybean (Non-Organic)	Incident	Brazil		2015
Soybean	Glycine max, Organic Soybean	Soybean (Non-Organic)	Incident	United States of America		2008
Soybean	Glycine max, Organic Soybean	Soybean (Non-Organic)	Incident	United States of America		2010 - 2017
Soybean	Glycine max, Organic Soybean	Soybean (Non-Organic)	Incident	Turkey	United States of America	2017
Soybean	Glycine max, Organic Soybean	Soybean (Non-Organic)	Incident	Malta	Italy	2007 - 2013
Soybean	Glycine max, Organic Soybean	Soybean (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Soybean Powder	Organic Soybean Powder	Soybean Powder (Non-Organic)	Incident	China		2012
Strawberry	Organic Strawberry	Strawberry (Non-Organic)	Incident	Turkey	Germany	2020
Sugar	Organic Sucrose	Sugar (Non-Organic)	Incident	India		2010
Sunflower Seeds	Helianthus Seeds, Organic Sunflower Seeds	Sunflower Seeds (Non-Organic)	Incident	Malta	Italy	2007 - 2013
Sunflower Seeds	Helianthus Seeds, Organic Sunflower Seeds	Sunflower Seeds (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Sweet Corn	Organic Sweet Corn	Sweet Corn (Non-Organic)	Incident	South Africa		2010
Sweet Potato	Organic Sweet Potato	Sweet Potato (Non-Organic)	Incident	China		2011
Sword Bean	Canavalia gladiata, Organic Sword Bean	Sword Bean (Non-Organic)	Incident	China		2011
Tamarind	Organic Tamarind	Tamarind (Non-Organic)	Incident	Mexico		2015
Textured Soy Protein	Organic Soy TVP, Organic Textured Soy Protein	Textured Soy Protein (Non-Organic)	Incident	China		2013
Tomato Paste	Organic Tomato Paste	Tomato Paste (Non-Organic)	Incident	China		2013
Tomatoes	Organic Tomatoes, Solanum lycopersicum	Tomatoes (Non-Organic)	Incident	Dominican Republic		2010
Tomatoes	Organic Tomatoes, Solanum lycopersicum	Tomatoes	Incident	Japan	Japan	2013
Vanilla Bean	Organic Vanilla Bean	Vanilla Bean (Non-Organic)	Incident	Philippines		2007
Vanilla Bean Seeds	Organic Vanilla Bean Seeds	Vanilla Bean Seeds (Non-Organic)	Incident	Philippines		2007
Vanilla Extract	Organic Vanilla Bean Extractives	Vanilla Extract (Non-Organic)	Incident	United States of America		2014
Vanilla Extract	Organic Vanilla Bean Extractives	Vanilla Extract (Non-Organic)	Incident	Philippines		2007
Vanilla Paste	Organic Vanilla Paste	Vanilla Paste (Non-Organic)	Incident	Philippines		2007

Ingredient	Ingredient synonyms	Adulterants	Record type	Produced location	Distributed location	Incident year
Vanilla Powder	Organic Vanilla Powder	Vanilla Powder (Non-Organic)	Incident	United States of America		2014
Vanilla Powder	Organic Vanilla Powder	Vanilla Powder (Non-Organic)	Incident	United States of America		2016
Vanilla Powder	Organic Vanilla Powder	Vanilla Powder (Non-Organic)	Incident	Philippines		2007
Vanilla Puree	Organic Vanilla Puree	Vanilla Puree (Non-Organic)	Incident	Philippines		2007
Vegetables	Organic Vegetables	Vegetables (Non-Organic)	Incident	Spain	Spain	2019
Vegetables	Organic Vegetables	Vegetables (Non-Organic)	Incident	Italy	France, Germany, Italy, United Kingdom of Great Britain and Northern Ireland	2015 - 2017
Vegetables	Organic Vegetables	Vegetables (Non-Organic)	Incident	China		2017
Warm Season Grasses (Unspecified, Organic)	Organic Warm Season Grasses	Warm Season Grasses (Unspecified, Non-Organic)	Incident	South Africa		2010
Water Chestnut	Organic Water Chestnut	Water Chestnut (Non-Organic)	Incident	China		2013
Watermelon	Organic Watermelon	Watermelon (Non-Organic)	Incident	Mexico		2015
Wheat	Organic Wheat, Triticum spp.	Wheat (Non-Organic)	Incident	Kazakhstan	Sweden, United Kingdom of Great Britain and Northern Ireland	2020
Wheat	Organic Wheat, Triticum spp.	Wheat (Non-Organic)	Incident	South Africa		2010
Wheat	Organic Wheat, Triticum spp.	Wheat (Non-Organic)	Incident	Australia		2019
Wheat	Organic Wheat, Triticum spp.	Wheat (Non-Organic)	Incident	Italy	Worldwide	2016
Wheat	Organic Wheat, Triticum spp.	Wheat (Non-Organic)	Incident	Malta	Italy	2007 - 2013
Wheat	Organic Wheat, Triticum spp.	Wheat (Non-Organic)	Incident	Italy	Austria, Belgium, France, Germany, Hungary, Italy, Netherlands, Spain, Switzerland	2007 - 2010
Wine (Oltrepo Pavese, DOC, Organic)	Organic Oltrepo Pavese Wine,DOC	Additives (Unspecified), Grapes (Alternate Varietal), Sugar, Flavor (Unspecified)	Incident	Italy		2020
Winter Squash	Organic Winter Squash	Winter Squash (Non-Organic)	Incident	United States of America		2020
Xylitol (Powder, Organic)	Organic Xylitol Powder, Organic Zylitol Powder	Xylitol (Powder, Non-Organic)	Incident	South Africa		2011 - 2012
Xylitol Syrup	Organic Xyiltol Syrup	Xylitol Syrup (Non-Organic)	Incident	South Africa		2011 - 2012

Annex 4 Bird's eye view food fraud vulnerability assessment of the organic potatoes', carrots', and onions' supply chains: Questions, selected vulnerability levels, and justification

Note: Opportunities-related questions are coloured light red, motivations-related questions darker red, and controls-related questions are coloured green. For opportunities answer option 1 to 3 reflect low to high vulnerability level, for controls the order is reversed.

Question number	Indicator	Question	Organic potatoes	Organic carrots	Organic onions	Justification
1	Ease of adulteration	Is it simple or complex to adulterate materials in the chain/sector?	2	2	2	Mixing organic and conventional produce is easy. Adulteration may be more profitable due to the higher prices of the organic produce, but since produce is in whole form, the number of adulterations are limited to extension with water and illicit preservatives' use.
2	Availability of knowledge and technology	Is the technology and knowledge to adulterate generally available in the chain/sector?	2	2	2	Relatively technologies are required to mix organic and conventional produce, for other types of adulteration more complex technologies are needed.
3	Level of detectability	How easily would adulteration in general be detected and what kind of methods are available?	3	3	3	Analytical detection of replacement of organic produce by conventional produce requires advanced laboratory analysis.
4	Ease of counterfeiting	Is brand counterfeiting an issue in this chain/sector?	NA	NA	NA	Counterfeiting of brands does not apply.
5	Ease of access in companies	How would you describe the production lines / processing activities in companies in this chain/sector?	2	2	2	Organic and conventional produce may be on site, with relatively easy access.
6	Supply chain characteristics	How would you describe the food supply chain?	1	1	1	Supply chain is relatively straightforward in the Netherlands when potatoes/carrots/onions are produced in the Netherlands. Business relationships are ad hoc with price being the main driver. Records on mass flow need to be recorded for organic produce.

Question number	Indicator	Question	Organic potatoes	Organic carrots	Organic onions	Justification
7	Historical evidence	Have fraudulent incidents of similar materials used and produced in this chain/sector been reported in the past?	1	1	1	See fraud incident listing in Annex 1: Few fraud incident reports for organic potatoes, carrots, or onions. A considerable number of incidents with organic products in the Netherlands as distributed country but not as producing country (most likely imported).
8	Supply and pricing	How would you define the supply and pricing in the chain?	3	2	1	Most price fluctuations for organic potatoes, followed by carrots, and onions showing more stable prices. Geography determines prices of all three commodities. Prices of substitutes (conventional produce) vary with their organic counterparts [20-23].
9	Price differences due to regulatory issues	Are there price differences as a result of regulatory differences across countries in this chain?	1	1	1	In the EU effect of regulations on price policy is the same everywhere.
10	Value-adding properties	Do special attributes or components determine the value of products in this chain?	3	3	3	Organic produce retails at a higher price than conventional produce.
11	Economic health	How would you describe the economic health of companies in this chain?	1	1	1	Ratio nett/total turnover is ~86% and similar for organic and conventional plant productions in the Netherlands, but higher than observed for animal productions [24]. International studies show that the net present value of organic farmers amounts +22-35% in comparison to farmers in regular productions and a +20-24% profit/cost ratio [20].
12	Business strategy	What are generally the characteristics of the business strategy of companies in this chain?	1	1	1	Generally, organic productions aim at many aspects of sustainable production. This includes long-term goals with many additional considerations.
13	Financial strains	How would you describe the financial strains imposed by companies in this chain/sector?	2	2	2	Average strains apply.
14	Level of competition	How would you rate the level of competition across the supply chain?	1	1	1	Financial competitiveness in the organic production sector is generally not too fierce, due to the premium prices and growing market [20]. Growth for organic vegetables production in 2019-2020 was 6% [22].
15	Ethical business culture	How would you describe the ethical business culture across the supply chain?	1	1	1	A part of organic farming is still based on common moral values and the mutual ethical principles which preserve, the real "soul" of perceived good farming. Ethics are therefore integrated in the original concept of organic production. Although some producers are primary economically driven towards the organic production, still many hold on to the original concept [25].

Question number	Indicator	Question	Organic potatoes	Organic carrots	Organic onions	Justification
16	Corruption level	How would you rate the corruption level (according to the Transparency International Corruption Perception Index) in the countries of the supply chain?	1	1	1	The Netherlands scores 82 out of 100, which reflects a low corruption perception index.
17	Criminal offences	How common are criminal offences across the supply chain?	1	1	1	Available for organic products, but not for organic potatoes, carrots or onions [14].
18	Level of fraud monitoring systems	How elaborate are the fraud monitoring systems in this chain?	1	1	1	Authentication schemes are usefully not employed.
19	Level of the verification of the fraud monitoring system	Are the fraud monitoring tasks of control systems in this chain/sector well verified?	1	1	1	Authentication schemes are usefully not employed.
20	Level of information system	How extensive are the information systems for internal control of mass balance flows in this chain?	2	2	2	Mass balance data are required for certification purposes, but integration of data with others in the chain or systematic analysis is usually not considered.
21	Level of tracking & tracing systems	How extensive are the tracking & tracing system in this chain?	2	2	2	No extensive systems usually.
22	Contingency measures	Do companies in the chain/sector generally have fraud contingency measures in place?	3	3	3	Usually no extensive, fraud-considering plans in place.
23	Level of integrity screening	How common is integrity screening of employees in this chain?	3	3	3	Few actors have this type of screening implemented.

Question number	Indicator	Question	Organic potatoes	Organic carrots	Organic onions	Justification
24	Level of ethical codes of conduct	How common are ethical codes of conduct or guidelines in place and embedded in this chain/sector?	3	3	3	Most actors are rather small-sized and do not have formal ethical codes of conduct.
25	Level of whistle blowing systems	How common are whistle blowing systems (system for reporting assumed fraudulent activities) in place in this chain?	3	3	3	SKAL operates an anonymous whistle blowing system [26].
26	Level of contractual requirements	Do contractual requirements with suppliers include elements that limit opportunities for fraud in this chain in general?	2	2	2	Mass balance records are part of the organic supply chain, and hence, of the contracts. No other special requirements.
27	Level of social control and transparency	How would you describe the social control and transparency of actions across the chain/sector?	1	1	1	Only regulatory certification, no additional self-regulating tools, no systematic communication about fraud across the chain or in the sector.
28	Level of fraud guidance	How well established is guidance for fraud prevention and control across the chain/sector?	1	1	1	Branch organization Bionext does not provide any guidance nor is raising awareness of fraud.
29	Level of food policy considering food fraud	How well covers food policy food fraud along the chain?	3	3	3	EU food policies clear about honest information to consumers, fair competition, and combating food fraud.
30	Level of enforcement	How well are fraud related laws enforced across the chain?	2	2	2	A risk-based approach is applied by SKAL (normal/elevated risk), but budgets limit the number of inspections. Fines have fairly limited financial impact unless companies have certification withdrawn.

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