



5th International Conference on Industry 4.0 and Smart Manufacturing Information Communication Tools in Alternative Food Networks

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Abstract

Effective communication in food supply chains is increasingly important, especially in supply chains that strive to provide improved levels of information from producer to consumer. Such supply chains can be found in alternative food networks. Alternative food networks often adopt local and short supply chain strategies to provide embedded information between producers and consumers. Information in the supply chain of alternative food networks is communicated through face-to-face, proximate, or extended supply chain structures. The tools used to communicate information vary amongst the supply chains in alternative food networks; for example, face-to-face may adopt word-of-mouth, while proximate and extended supply chain structures may use labels, digital platforms, and websites. This paper uses Principal Component Analysis to provide an understanding of the categories and underlying dimensions of information communication tools in the supply chains of alternative food networks. A living lab approach and survey method were used for data collection. Using Principal Component Analysis, the data revealed two principal components of information communication tools, highlighting the use of on-packaging information communication tools such as packaging and labelling tools as a principal component. Another principal component was identified, backing a need for off-packaging information communication tools such as digital technologies, certificates, social media, and packaging technologies, enabling stakeholders who desire a further understanding of information regarding the processes and products. The paper concludes with the implications, limitations, and areas of future work.

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1. Introduction

Consumers, business-level stakeholders, and governments increasingly seek to enhance their access to information in the food supply chain, reflecting the drive to create embedded information flow within food supply chains. Alternative food networks (AFNs) and their supply chains aim to meet this need by reducing physical and social distances between producers and consumers [1]. Supply chains in AFNs focus on developing strategies around quality and sustainability-related outcomes, aiming to create value, drive socio-technical innovations, and build producer associations [2]. At

the consumer level, there are differences in the desire to understand the product's origin and consumer motivation to understand the provenance [3,4]. Processing and retailing are locally based, diverse in size, scale, and offerings, and built on quality and transparency [5]. Institutional frameworks are locally oriented, where a local authority is involved and has reduced levels of bureaucracy. In contrast to global food supply chains, associational frameworks are relational and trust-based, formulated regionally, and can also be collaborative [2].

AFNs encompass supply chains that aim at providing sustainable and alternative products compared to the global food supply chain [6]. AFNs attempt to reduce social and physical distances and provide embedded information throughout the supply chain [7]. There are two distinct actors in AFNs, producers and consumers; an intermediary in-between is also possible, i.e., a small-scale processor or speciality retailer. Also, logistic and transport actors and secondary actors, such as universities, research institutes, authoritative organisations, and service providers, can be involved [8]. Characteristics of AFNs include disintermediation, personalised relationships, direct interaction, and short distances. Another central trait of the AFN is to help consumers make informed choices when purchasing food products, thus requiring embedded information over production, processes, practices, and products [9].

Traditionally, information in food supply chains is provided through information communication tools such as labels that are based on quality management systems and claims [10]. Labels can be valuable for information communication, particularly for knowledgeable and well-informed consumers [12]. However, in some instances, labels can cause information overload and a misunderstanding of information for consumers [13]. Information in AFN supply chains is communicated through face-to-face, proximate, or extended channels [6,7]. Farmers and consumers interact directly in the face-to-face supply chain, and this approach develops trust through benevolence [14]. Proximate, where a locally based company (intermediary) can give product information. Extended supply chain structures often use labels to provide information, raising challenges like mistrust and misunderstanding of information. Trust in the proximate and extended channels has been developed through a certain level of credibility and integrity of supply chain stakeholders [14]. Supply chains that do not use face-to-face channels, for example, catering companies (i.e. restaurants), e-commerce, and speciality retailers [15–17], may require labels, technologies, and other communication channels.

Existing research sheds light on how products are distributed and sold in AFNs, for example, in [6] highlighting the use of on-farm sales, box schemes, local farm markets, speciality retailers, and online sales. In addition, the ways information is shared are identified, like social media, mouth-to-mouth communication, and company websites, to name a few [18]. Communication tools used in AFNs may vary based on supply chain types (face-to-face, proximate, and extended). The categories of communication tools used in the supply chains of AFNs can provide insight into developing better information sharing. Both online and offline tools are recognised to support stakeholders' understanding of products and processes in the supply chain [18]. However, the categories of information communication tools and their underlying dimensions in the supply chains of AFNs have yet to be studied in detail. The research presented here aims to classify the principal components of information communication tools in the supply chains of AFNs from a stakeholder's usage perspective. In addition, the research seeks to provide an understanding of the information communication tools' role in information sharing in the supply chains of AFNs.

The remainder of the paper is structured as follows. Section 2 presented an overview of information communication tools used in food supply chains. Section 3 is the Methodology, followed by Section 4, the Results. Section 5 is the Discussion, and Section 6 Concludes, presenting areas for future work.

2. Information Communication in Alternative Food Networks

Information flow in supply chains refers to sharing data amongst supply chain stakeholders, including data on orders, product information, inventory-related data, and logistics data (e.g., delivery times). Supply chain information can flow upstream and downstream throughout the supply chain stakeholders [19]. It can be a one-way information flow (bottom-up or top-down) or a two-way information flow throughout the supply chain [20]. It can be both through online (e.g. social media, websites) and offline (labels, face-to-face) communication methods [18]. [18] illustrates how information flows in alternative (short) food supply chains using both online and offline mediums, see Fig 1.

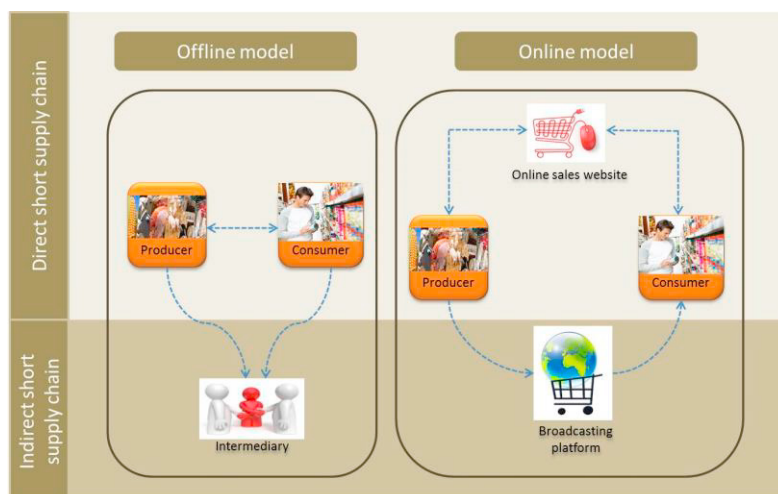


Fig. 1 Online and Offline Information Flow in Supply Chains of AFNs Adopted from [18]

Communication tools are used to support information flow between producers, intermediaries, and the consumer. Tools for communicating information in alternative food networks have been identified in the literature, including labels, face-to-face, certificates, digital platforms, digital packaging technologies, and social media [18,21,22]. Table 1 provides an overview and description of information communication tools in food supply chains.

Table 1. Example of Information Communication Tools in Food Supply Chains

Information Communication Tool	Description	Reference
Labels and packaging	Any words, particulars, trademarks, brand name, or pictorial matter relating to any foodstuff and placed on packaging, document, notice, label, ring or collar, accompanying or referring to such foodstuff.	[23]
Social Media	Internet-based applications allow for the development of user-generated information and provide a forum for users to interact with each other.	[24]
Face-to-Face	Face-to-face communication refers to the direct interaction between two stakeholders in the supply chain; this type of word-of-mouth communication is possible where there is close, if not direct, interactions in the supply chain.	[6]
Digital Packaging and Scanning Technologies (QR Codes)	Digital packaging and technologies for communication carry data regarding a foodstuff, for example, relating to traceability, processing, and logistics data.	[25]
Certificates	A screening tool that enables stakeholders to make supplier selections in unobservable supply chain situations.	[26]
Digital platforms and websites	The communication of information in the supply chain through digital platforms and websites. They can increase transparency, support the ability to rebuy products and support a shorter supply chain through embedded information and transparency.	[21,27]

Digital platforms and websites are emerging to support information communication throughout the supply chain. Various applications have emerged where digital platforms can be used to support more traditional communication tools. For example, blockchain technology can support consumers' trust in products by holding actors accountable for the information and claims presented on product labels [21]. Digital platforms have also emerged in the supply chains of AFNs, showing the consumer's desire to increase supply chain transparency and provide an easier route to purchasing products. Also discussed is that digital platforms should retain the uniqueness of alternative food products and that not all AFNs require digitalisation [27]. Some of the critical requirements in digital platforms in the supply chains of AFNs have been highlighted and include track and traceability, real-time operations and supply chain data, real-time supplier insights and origin information, transparency, real-time data on quality, and indicators relating to sustainability and risks [28,29].

Labels are used to communicate information to consumers in supply chains. [23] suggest labels are used to give consumers an understanding of food products and processes. The same research by [23] suggests that information presented on labels is coherent for some consumers, while many people find it difficult to understand. Labels hold both mandatory information and voluntary information. Mandatory labelling refers to horizontal and vertical rules set out under directives. Voluntary information on labels includes aspects such as origin, quality, sustainability, and organic production, to name a few [30]. Labels are helpful; they explicitly provide information to consumers, particularly regarding ingredients and nutrition, which are often mandatory food regulatory requirements [12]. The voluntary labels may not be as comprehensive to consumers; for example, sustainability and quality-related logos and claims on labels may confuse consumers who do not fully grasp the information presented [13]. Such voluntary labels may require supporting tools to communicate information to those stakeholders seeking a deeper understanding.

Social media is also a way for producers to provide information to consumers and, more popularly, directly interact with them, supporting the concept of short and alternative food supply chains [31]. In the short food supply chain, social media provides benefits such as low costs of adoption and usage, the potential to attract young customers, the ability to collect customer information to improve promotions, and the ability to receive real-time feedback. Mistrust in social media content and inconvenience are two critical constraints for adopting social media in food supply chains [32]. Social media platforms are increasingly popular for communicating information between businesses and consumers; they open a more open information flow between the producers, businesses and consumers involved within the food supply chain [18].

Face-to-face, word-of-mouth communication is a common feature of the supply chains in AFNs [6]. It encompasses direct interaction between two stakeholders. In this communication tool, stakeholders in the supply chain meet face-to-face to exchange information about a product through word of mouth. Dedicated producers driven to improve sustainability prefer this strategy to use other tools like certificates and labels [33]. Food supply chains that use this include on-farm sales, community-supported agriculture, and specialised farmer's markets [6]. Such communication tools are helpful for situations where producers and consumers interact directly to provide and receive information regarding the food supply chains. Although this information-sharing approach provides a feeling of trust, consumers still need help understanding the presented information.

Becoming certified, or certification, is the voluntary assessment of approval by a third party or accredited body [34]. [33] study the use of certifications in alternative food networks, particularly in short food supply chains, from the stakeholders' perspective. In their research, [33] show that business-level stakeholders who want to share information with consumers prefer to use something other than certification schemes and would rather have a face-to-face approach. At the same time, producers that are more economically driven and those that have an intermediary are more inclined to adopt such certifications. Another trend in the supply chains of AFNs is the use of participatory guarantee systems as a substitute for third-party certificates. Such systems allow bottom-up decision-making and inclusive control over supply chain processes [35].

Digital packaging and scanning technologies have emerged to support information flow in the supply chain. Those carrying information from one stakeholder to another are called data carriers. Data carriers or automatic identification devices are often used to support supply chain automation and traceability [25]. These devices include barcodes, radio frequency identification tags, and QR codes [36]. Intelligent systems and digitalisation can support logistics and distribution management in the supply chain of alternative food networks [37], highlighting unique benefits in supporting sustainability objectives.

3. Methodology

This research is of exploratory design and is in three main steps. Step 1 involves the identification and selection of information communication tools. This is done through a literature review, followed by online meetings with four experts to confirm a list of communication tools that were identified in the literature. The group of experts in this study were from two companies. Company A is a blockchain solution developer and provider in the food industry, in which the platform can be customised towards various food industry applications. The company offers several

products and services, including blockchain solutions, blockchain labs, masterclasses, expert placement, SDG consultants and blockchain auditing services. In the use case, the company is investigating blockchain technology to improve transparency in sustainable food supply chains. Company B is a micro-size company that offers a blockchain-based service platform for the catering industry. The experts in both Company A and B aim to support traceability, information sharing, and overall transparency in food supply chains. The experts have a rich and balanced understanding of the food industry regarding information communication tools, from more basic tools to more modern ones, such as blockchain technology. In addition, blockchain technology is used mainly to support existing communication tools, like certificates, labels, digital labelling technologies, and other digital platforms and websites. Hence, their knowledge and expertise are not limited to blockchain technologies. Step 2 was the questionnaire survey focusing on information communication tools applicable to supply chains in AFNs. The study participants were asked on a 5-point Likert scale about the extent to which they use the information communication tools (from step 1) to access information in alternative food networks. See Table 2 for the list of communication tools (factors) used in the analysis. Step 3 involves clustering the communication tools into higher-level categories. This is done using Principal Component Analysis (PCA). PCA is a mathematical approach towards gathering and grouping factors into components [38] and is a useful tool for compressing and aligning factors into components, providing simplified data analysis and assisting in the analysis and observations of variables [39]. This research uses PCA to generate the principal components (higher-level dimensions) from grouping the information communication tools. Responses were imported into SPSS, checked, and verified for accuracy. Dimension reduction technique was applied for the PCA, selecting factors from each question category. Direct Oblimin rotation was adopted, which is a popular approach in PCA when there are some assumptions that the variables may correlate. Based on the results of the PCA, principal components for the communication tools are developed. The flow chart for PCA is shown in Fig 2. The suitability of PCA was tested using KMO and Bartlett's test, where the KMO value should be above .500, and Bartlett's test of Sphericity P value should be below .05. As shown in Table 3, the values suggest that PCA is suitable, however, is approaching the threshold with a KMO value of .630 [40].

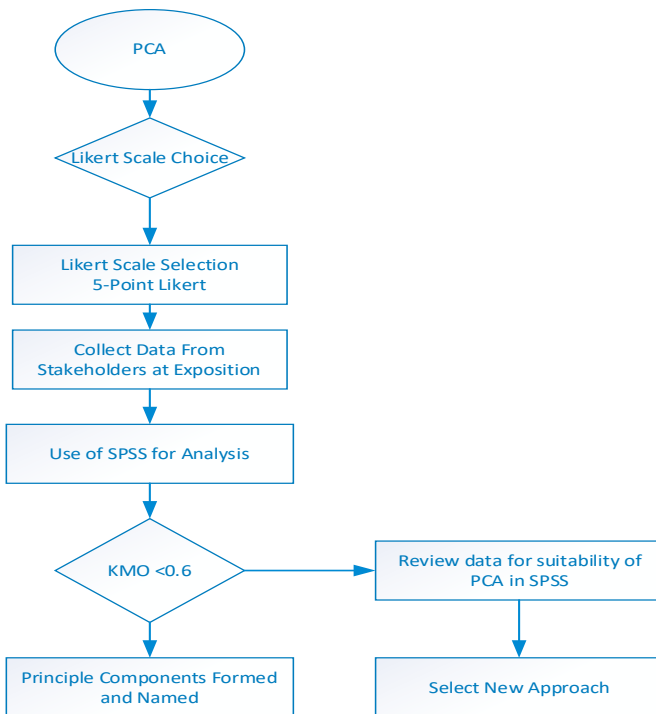


Fig 2. Principal Component Analysis Process

Table 2 List of Information Communication Tools (Factors)

Information Communication Tools (CT)	
CT1	Labels and packaging
CT2	Social Media
CT3	Face-to-Face / Word of mouth
CT4	Digital packaging and scanning technologies (QR Codes)
CT5	Certificates
CT6	Digital platforms and websites

Table 3 KMO and Bartlett's Test Information Communication Tools

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.630
Bartlett's Test of Sphericity	Approx. Chi-Square	172.024
	df	15
	Sig.	<.001

4. Results

Descriptive statistics are used to summarise the profile of participants. As no personal identifiers, such as age, gender, or income, were collected, participants are profiled regarding their role in AFNs (consumer, business level stakeholder, not involved at all, multiple-roles), their time involved in AFNs, representing their active time buying, selling, or operating in such networks, and the frequency of purchases, referring to the number of times per month/week in which products are bought. An overview is shown in Table 4.

Table 4. Descriptive Statistics: Participants Overview

Role in Alternative Food Supply Chains		Time involved in AFNs		Frequency of purchases	
Selection	Frequency	Selection	Selection	Selection	Selection
As a supply chain practitioner/Business level stakeholder	6	No involvement	17	Never	10
As a consumer	99	0 to 3 years	48	Less than one time per month	14
I am not involved in short and local food supply chains	11	4 to 6 years	22	About one time per month	16
Both	18	7 to 10 years	13	Several times per month	25
I prefer not to say	1	More than ten years	26	About one time a week	41
Total	135	I prefer not to say	9	Several times per week	24
		Total	135	I prefer not to say	5
				Total	135

Participants were asked to rank on a 5-point Likert the extent to which they use the communication tools to access information in the supply chains of alternative food networks. Labels and packaging were most used according to the responses, followed by face-to-face, certificates, digital platforms and websites, and last was social media. See Table 5 for the descriptive statistics regarding the use of information tools.

Table 5 Descriptive Statistics: Extent to which Participants Use Each Information Communication Tool

	N	Not at all	To a slight extent	To some extent	To a moderate extent	To a great extent	Mean	Std. Deviation
Labels and packaging	134	4	6	32	43	49	3.95	1.028
Social Media	134	27	17	38	38	14	2.96	1.283
Face-to-Face / Word of mouth	134	4	19	27	48	36	3.69	1.105
Digital packaging technologies (QR Codes)	134	26	25	40	38	5	2.78	1.166
Certificates	134	10	23	40	37	24	3.31	1.172
Digital platforms and websites	133	22	16	33	43	19	3.18	1.308

The Kruskal–Wallis test was used to test the variance between the groups concerning the questions on information communication tools between the three groups. A significant difference occurs when the p-value > .05. As shown in Table 6. Table 6 shows few significant statistical differences between the participants in AFNs, except when looking at the role in alternative food supply chains and the use of digital platforms, websites, and certificates. Also, a significant difference is noticed between the frequency of purchases and the use of digital packaging and scanning technologies. The PCA revealed two principal components (PCs). PC 1 (41.48% of the total explained variance) is called off-packaging information communication tools. Such information communication tools require stakeholder inquiry and engagement through digital platforms, websites, and word-of-mouth. PCs 2 (17.08% of the total explained variance), labelled On Packaging Information Communication Tools, represents a conventional and mainstream form of information communication on food products, i.e. labels and packaging. See Table 7 for PCA results for Information Communication Tools.

Table 6 Summary of Information Communication Tools Variations

Information Communication Tools			
	Role in Alternative Food Supply Chains	Involvement over time	Purchasing Behaviour
Digital platforms and websites	< 0.001	0.785	0.763
Digital packaging and scanning technologies (QR Codes)	0.499	0.94	0.037
Social Media	0.659	0.387	0.343
Certificates	0.023	0.333	0.282
Face-to-Face / Word of mouth	0.163	0.308	0.766
Labels and packaging	0.603	0.628	0.300

Table 7 Principal Component Analysis Results of Information Communication Tools

Information Communication Tools	Information Communication Tools	
	PC1: Off-Package Information Communication Tools	PC2: On Package Information Communication Tools
Digital platforms and websites	0.802	
Digital packaging technologies (QR Codes)	0.760	
Social Media	0.737	
Certificates	0.667	
Face-to-Face / Word of mouth	0.507	
Labels and packaging		0.883

4. Discussion

The Kruskal–Wallis Test showed significant statistical differences between participant types and factor ratings. There were variances between the information communication tools of digital platforms and certificates. These differences may be attributed to the fact that those involved in the short and local alternative chain are more ascertained to prioritise these aspects variables differently than those not involved. PC1 represents the “Off Package Information Communication Tools”. Off-package information communication tools are useful for conveying information to stakeholders who want to know more than what is presented “On-package” [41]. For example, when a stakeholder, i.e. the consumer, wants to find more information about a product, they can scan a code and be brought to a digital platform. The digital platform must provide the right information that consumers desire, showing a need for research in information requirements across AFNs, highlighting a need for research on information needs in AFNs. Trust in food supply chains can be supported using digital technologies. Consumers and stakeholders who distrust information presented on labels or claims can use digital platforms with more information regarding the product and processes within a supply chain [21]. In addition, the ability to support a type of transparency that allows information flow throughout the supply chain can support the needs of stakeholders within such alternative food supply chains [27]. It is essential to consider the needs of stakeholders within and between AFNs, as, for example, small-scale face-to-face initiatives or those based around community-supported agriculture may not benefit from the adoption of digital technologies. Social media provides a unique opportunity for stakeholders to provide and access information in the supply chains of AFNs, supporting recent literature [31]. They might support a more two-way information flow in the supply chain, reinforcing [18] to allow for a more inclusive information exchange process. Although it still appears to be a moderately used tool to engage with information, many participants are not overly engaged with social media as a communication tool, reflecting a lack of trust in such approaches [32]. Certificates are deemed valuable tools for providing and accessing information. These certificates could be linked to offline and online approaches. For example, certificates can be uploaded on digital platforms and websites, where consumers can access these through digital packaging technologies or directly through the company's website. The consumer could receive such information from a producer or intermediary in the supply chain on offline tools. In both cases, the information on the certificate would be request-based. The face-to-face communication tool is highly linked to the development of AFNs, as it links producers directly to consumers [6]. These results revealed that this tool is used to a moderate to high extent, showing the applicability of its structure. The face-to-face structure requires time and commitment for conveying information from producer to consumer, and the use of tools that facilitate the information, such as QR codes and digital platforms located in on-farm shops, could facilitate the information communication.

PC 2 is the information provided on the label and packaging. “On-Package Information Communication Tools” refers to the information presented on labels and packaging and can include voluntary information, such as quality and sustainability claims, or mandatory information, like nutrition and ingredients [41]. Information and claims can be communicated here through logos and text. Many nations have strict regulations regarding what can and must be communicated. This is still the most used way of providing information to the consumer; however, as consumers desire to gain a deeper understanding of their food products, the use of off-package information communication tools increases. In this study, labels and packaging are found to be the most used information communication tool in alternative food networks among the participants. This result is unsurprising as it is an on-packaging information communication tool that provides information directly from upstream stakeholders of the supply chain towards downstream supply chain stakeholders [23]. Some labels are mandatory, reflecting governmental regulations on ingredients. Other voluntary labels can also be used to claim sustainability or quality performance [30]. In the supply chains of AFNs, conveying information through claims may be difficult and expensive, limiting the benefit of such tools across these chains [3]. PC1, "off package information communication tools", and PC2 ", on package information communication tools", can relate to both online and offline communication, as shown in [18]. This is shown in Fig 3. Off-package information communication tools can be online or offline; for example, face-to-face communication or communication through certificates can be seen as both online and offline. Certificates may also be digitised and, therefore, fall under both online and offline categories. Digital packaging and scanning technologies, digital platforms and websites, and social media support more online channels. Labels and packaging in PC2 are used in offline communication modes, where there is limited direct interaction between the farmer and consumer, such as extended AFN supply chain structures [6].

The key implications in the study include i) labels are still the most used way for consumers to obtain information related to food products in alternative food supply chains, thus, good labelling practices need to be maintained; ii) Off-packaging communication tools become useful when there is a desire to gain a more in-depth understanding of products within the chain. Assessing the various tools and their impact on trust and transparency is required; iii) Digital technologies may be helpful in enabling trust in alternative food supply chains, stimulating a need to understand the information requirements across chains; iv) Certificates are useful request-based tools in providing additional assurances regarding claims in both online and offline forms of communication. Developing accessibility and usability to such claims may be useful as consumers' demand for transparency regarding claims increases; v) Digital platforms, digital packaging technologies, and social media provide an opportunity to create a more dynamic and two-way flow of information, developing a more modern approach to face-to-face communication.

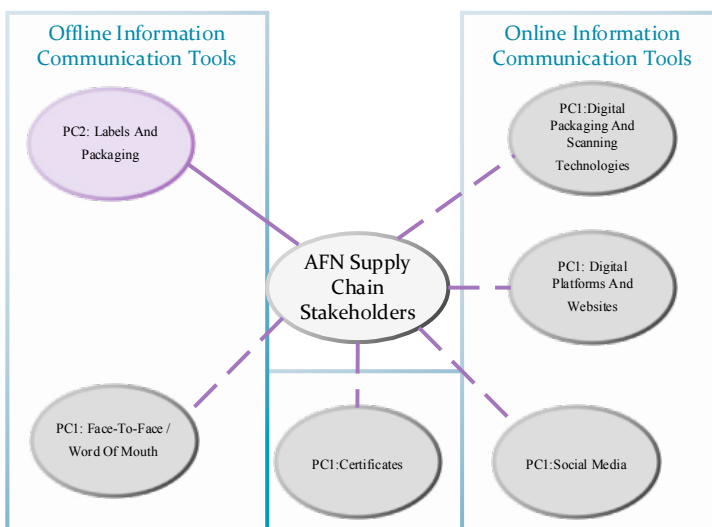


Fig 3. Relating Information Communication Tools to Online and Offline Communication

5. Conclusion

This research aimed to identify the higher-level dimensions of information communication tools in the supply chains of alternative food networks. The principal component analysis shows two dimensions (principal components) of information communication tools. Several key findings are: 1) There are two principal components for communication tools in the supply chains of alternative food networks, namely on-packaging information communication tools (provided directly) or off-packaging information communication tools (requires inquiry). 2) In the proximate and extended types of alternative food networks, labels and packaging will remain an important communication tool for claims and information provisioning and likely the first place consumers will look to find information. 3) Off-packaging information communication tools such as digital platforms and websites, social media, digital packaging technologies, certificates and word-of-mouth can be seen as supplementary sources of information, used not only to convey a claim but to communicate further information relating to that claim. These communication tools are becoming more attractive as consumers in the supply chains of AFNs look for ways to understand sustainability practices and outcomes. 4) Digital technologies hold favourable characteristics to support information communication in supply chains and provide an opportunity to improve two-way communication. The research presented here has its limitations. First, the study was conducted in the Netherlands, and further research may benefit a more global understanding of communication tools to support supply chains in alternative food networks. Second, most participants were in the role of the consumer. Although this provides valuable insight into how they interact with communication tools, it would be valuable to include other levels of stakeholders, e.g. companies, governments, and producers. Finally, the list of tools assessed is those that are generalised. Future work can focus on each type of communication tool, for example, a more comprehensive study on various digital platforms or types of certifications and claims. Finally, this study focused on using information communication tools in the supply chains of alternative food networks to access information. Future work can dive deeper, focusing on how such tools play into transparency and trust across the chain.

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