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Elimination of Bottlenecks of Short Food Chains by Technological and Non-technological Innovations in Short Food Supply Chains

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ABSTRACT

The objective of this work is to identify the typical problems, barriers, needs of the Short Food Supply Chains (SFSCs), and the appropriate technological and non-technological innovations for improving their performance and to identify and characterize their applicability.

With the analysis of these inventories of the typical needs of the SFSCs and the solutions, such patterns of strengths and weaknesses can be established, which can be used for the identification of the typical bottlenecks and potential success factors of SFSCs.

The rapid development of digital technologies provides a range of new enabling functions of solutions, which can be adapted for SFSCs.

Keywords: short food supply chain; food chain, SFSC; innovation, digital solutions

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Introduction

Short food chains face several challenges in meeting the needs of consumers and in ensuring feasible operations for their chain members. One of the objectives of the SmartChain H2020 project is to identify the typical needs of the short food supply chains (SFSCs) and the appropriate technological (TECI) and non-technological (NTI) innovations for improving the performance of short food supply chains and to identify and characterize their applicability. The objective of the work described in this report is to prepare an inventory of the typical needs of the SFSCs and the solutions, which can be used for the elimination of their weaknesses and to analyze these inventories for establishing such patterns of strengths and weaknesses, which can be used for identification of the typical bottlenecks and potential success factors of SFSCs.

By systematic step-by-step analysis of the weaknesses of the short food chains in satisfying the needs of the consumers and the needs of their chain members for a financially feasible operation along the chain, the typical weaknesses of the SFSCs and their causes can be identified. This enables the targeted collection of applicable technological and non-technological innovative solutions for elimination or reduction of these weaknesses. The innovative solutions can be identified from good practices of the SFSCs and other sources of knowledge available from the experiences of the project partners and the literature. The rapid development of digital technologies provides a range of new enabling functions of solutions, which can be adapted for SFSCs.

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1. Method

A systematic analysis of the needs of the SFSCs for technological and non-technological innovations was carried out by the following procedure.

Step 1. Identification of the explicit and hidden needs of the SFSCs of innovation

The explicit needs of the SFSCs for technological (TECI) and non-technological innovations (NTI) were identified by analyzing of the information received from the 18 cases of SFSCs from 9 countries (Switzerland, Germany, France, Greece, Hungary, Italy, Netherlands, Spain, Serbia) participating in the Smart Chain project through a questionnaire survey with the assistance of project partners acting as hubs in these countries.

First short summaries were prepared from the answers. From the short summaries, the explicit needs of the SFSCs were identified and collected.

The explicit needs of the SFSCs for TECI and NTI were compared to the research and innovation needs of food businesses and from practical experiences and by adaptation of the needs described in the "Scientific and technical needs of the food and drink supply chains 2018-2020" (Campden BRI, 2018).

Based on the similarities and gaps between the research and innovation needs of the food chains in general and the specific explicit needs of the SFSCs represented by the case studies, the potential hidden needs of SFSCs were identified in addition to the explicit needs.

The explicit and hidden needs were organized into an inventory of the needs of SFSCs.

Step 2. Collection and description of technological and non-technological innovations for SFSCs

Innovative methods, solutions, and systems were collected based on the innovativeness and applicability of SFSCs, from a wide range of sources including the 18 case studies in the SMARTCHAIN project, the knowledge, experiences of the project partners, publicly available information, literature review, results of other projects, such as SKIN (2019), Finish (2016), TRUEFOOD (2010), I-CON (2019), CapinFood (2014). These include technological (TECI) and non-technological innovations (NTI) for the individual steps of the SFSCs and SFSCs as a whole vs. needs of consumers and needs of the chain actors.

The short summaries were used to identify those innovative solutions, which were developed by the case studies to tackle their problems and to improve the performance of their SFSCs.

Additional innovative solutions were collected also to tackle those problems, which were described by the cases, but were not known, mentioned, or used by the cases and for the hidden needs of the SFSCs.

Step 3. Descriptions of each specific innovative solution, which were kept after the first screening

The key information on each innovative solution was described.

These innovations were organized into an inventory of innovative solutions based on the following topics:

- Agriculture and primary production
- Food safety and hygiene aspects and regulatory issues related to technological and non-technological innovation
- Food quality aspects
- Food preservation and other processing technologies including preservation of freshness and nutritional value and- packaging from
- Logistics, accessibility of the product and short food chain channels

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- Food integrity, traceability, transparency, certification, voluntary labeling, food chain management, and networking
- Marketing concepts and communication tools
- Structural and economic aspects, enhancing collaborative short food supply chains
- Modern information and communication technologies (ICTs)

A short description tool of innovative solutions was prepared for each innovation, which contains the main information like:

- the reference to the analyzed case study or the source of the information,
- the title of the technological or non-technological innovation
- the description of the need or the problem
- The description of the technological or non-technological innovation.

Step 4. Categorization of TECIs and NTIs into the overview matrix

The collected innovations were categorized as those, which serve the needs of the consumers (food safety, food quality, trust, ethical aspects, accessibility) and the needs of the chain actors (fair price, increased negotiating power, shared use of available resources, product development support, access to markets and consumers, access to infrastructure). They were allocated to the different individual steps of the SFSCs, and to the food supply chain as a whole (product integrity/ authenticity, transparency, marketing concepts, food chain management and networking for enhancing cooperation among chain actors, business modeling, policy environment, legal requirements, labeling)

The availability of the applicable innovative solutions for the different needs of the SFSCs was reviewed and the gaps were identified.

2. Results

54 short summaries of the needs and innovative solutions described by the 18 cases were prepared.

3. Typical problems, barriers and needs of the short food chains (Inventory of the Needs)

Based on the analysis of the short summaries the following typical problems and needs were identified:

Typical problems and needs of the cases (Inventory of the needs)

From the 18 cases and the literature survey the following problems, needs were identified:

- ***Limited volume:***
  - high uncertainty, fluctuation of product volumes;
  - unpredictable supply of raw materials
  - high cost of meeting retailers' requirements

- ***Perishability of some fruit, vegetable, meat, dairy products:***
  - post-harvest decay caused by plant pathogens, spoilage organisms, moulds, reducing shelf life
  - short shelf-life
- ***Limited infrastructure, technical resources, limited financial resources for investment for improving technical capabilities:***
  - waste management, particularly during markets
  - lack of IT systems
  - lack of infrastructure, building, machinery for handling goods;

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  - production infrastructure
  - financial liquidity, financial and human resources;
- ***Limited availability of labour force:***
  - difficulties to employ people because of the weekend, holiday work
  - difficulties in time management
- ***High cost of logistics/product unit:***
  - high cost of transport due to small volume, simplifying and streamlining logistics because of small scale, low margin
  - lack of efficient cold chain
- ***Poor direct access/links to consumers – low awareness of consumers:***
  - lack of information of consumers about the products (also about their natural product appearance, operation, benefits of the SFSCs and their availability
  - lack of information on consumer's needs, market trends
  - matching consumers' purchasing willingness and producers' willingness to produce
  - limited access to market (time, cost, visibility caused by the national legislation
  - too long concession renewal time of a market, uncertainty for the farmers
  - lack of consumer awareness of the quality benefits vs weight loss of aged beef
- ***Lack of trust of consumers***
  - lack of understanding of the benefits offered by SFSCs by consumers (hidden)
  - lack of trust of consumers in food safety, authenticity of the products
  - bad image of agriculture in the society, low trust
  - anti-campaign by hard core animal right activists and Vegans
- ***Low negotiating power with retailers, large service/ utility providers, large customers, intermediaries, municipal government:***
  - limited negotiating power to achieve fair price;
  - fluctuating prices along the season
  - limited negotiating power with a big retailer, incoherent promotion
  - lack of direct sales through an authorised representative
  - limited negotiating power with the city government
  - selling at lower price than actual value because of the fear of competitors
  - long delivery time of glass jars
- ***Relatively high price – low adaptability to price competition:***
  - high competition on the juice market
- ***Lack of information and knowledge of product development skills, new, advanced technologies, marketing, and awareness of public funding opportunities, understanding of and compliance to legal requirements:***
  - limited human resources for complex administration
  - lack of professional staff

- *Food safety:*
  - difficulties to ensure compliance to phytosanitary management/ food safety
  - requirements; (cost of traceability); stringent requirements for processed products; animal welfare and traceability
  - difficulties in protecting authenticity
- *Food quality:*

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  - lack of knowledge to prepare labels to comply legal requirements compliance to food service certification demands
  - nutritional labelling
- *Product development, marketing, business skills*
  - lack of product development skills (too narrow product line,
  - lack of process/technology development skills
  - lack of marketing, and business development skills;
  - lack of management skills, lack of trust with employees
  - low willingness to pay for training
  - automated stock control program in 2 webs-hops and 1 shared store
  - national legal ban on serving medium rare beef in spite of the pathogen certificate
- ***Lack of collaboration with peers, other SFSC members:***
  - lack of willingness on shared use of resources,
  - actions for common, mutual benefits; for logistics
  - lack of experience to collaborate on shared use of resources, actions for mutual benefits, common interests
  - lack of understanding the market potential of heathy foods, healthy diet (hidden)
  - lack of understanding the market potential of ethical production (hidden)
  - lack of understanding the market potential sustainable production, meeting circular economy requirements
  - lack of understanding the impact of voluntary standards and certification
  - lack of understanding the enablers of digital technologies

These needs, problems match very well with the original categories defined in the overview matrix (Table 1.), but they provide a more accurate explanation of the real needs. During this comparison it was established while all needs related to the needs of the consumers and the chain actors were covered related to the operation of the individual steps of the value chains, relatively few needs were mentioned related to the operation of the food value chain as a whole. For this aspect mainly the use of some marketing concepts and the compliance to legal requirements were mentioned, but the need for tools that support the authenticity, transparency, food chain management, business modeling, certificates were not mentioned by the case studies. This indicated that the majority of SFSCs are not aware of the existence and benefits of such tools, methods, solutions, what they can apply.

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Table 1.: Matching the needs identified by experience and the needs summarised from the responses of the cases by cases

		individual steps of the SFSC						
		farming	primary production	transport	processing and packaging	storage	logistics	sale
needs of the consumers (citizens)	food safety	Perishability of some fruit, vegetable, meat, dairy products Poor direct access/links to consumers – low awareness of consumers Lack of information and knowledge						
	food quality	Perishability of some fruit, vegetable, meat, dairy products Limited availability of labor force Poor direct access/links to consumers – low awareness of consumers Lack of information and knowledge						
	trust	Perishability of some fruit, vegetable, meat, dairy products Poor direct access/links to consumers – low awareness of consumers						
	sustainability	Poor direct access/links to consumers – low awareness of consumers						
	ethical aspects	Poor direct access/links to consumers – low awareness of consumers						
	accessibility	The high cost of logistic/product unit Poor direct access/links to consumers – low awareness of consumers Lack of information and knowledge						

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needs of the chain actors	fair price	Relatively high price – low adaptability to price competition
	increased negotiating power	Limited volume Limited availability of labor force Low negotiating power with retailers, providers Lack of collaboration with peers, other SFSC members
	shared use of available resources	Limited volume Limited infrastructure, technical resources, limited financial resources for investment Lack of collaboration with peers, other SFSC members
	product development support	Lack of information and knowledge
	access to markets and consumers	Limited availability of labor force Lack of collaboration with peers, other SFSC members
	access to infrastructure	Limited infrastructure, technical resources, limited financial resources for investment Lack of collaboration with peers, other SFSC members

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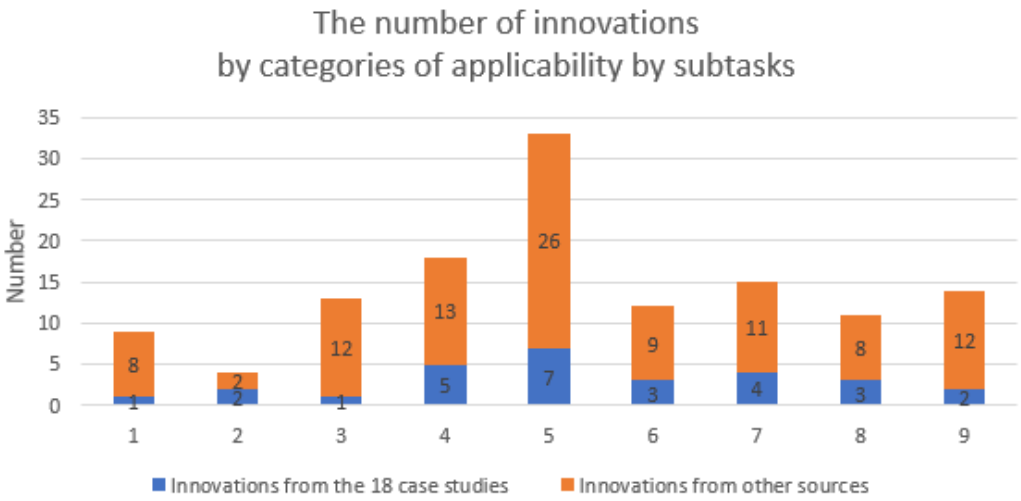
4. Analysis of the needs and the related innovative solutions

Altogether 129 innovative solutions were identified, which were collected into the inventory of the innovative solutions.

Their distribution according to categories of applicability in different areas is shownin Figure 2.



1. Agriculture and primary production
2. Food safety and hygiene aspects and regulatory issues related to technological and non-technological innovation
3. Food quality aspects
4. Food preservation and other processing technologies including preservation of freshness and nutritional value and– packaging from
5. Logistics, accessibility of the product and short food chain channels
6. Food integrity, traceability, transparency, certification, voluntary labelling, food chain management and networking
7. Marketing concepts and communication tools
8. Structural and economic aspects, enhancing collaborative short food supply chains
9. Modern information and communication technologies (ICTs)

Figure 2.: The number of innovations by categories of applicability by the different aspects

It can be established that for all areas of potential applications some innovations were found. The largest number of innovations were found for the “Logistics, accessibility of the product and short food chain channels” followed by the food preservation and other processing technologies including preservation of freshness and nutritional value and packaging. Nearly the same number of innovations were identified for the category “Marketing concept sand communication tools and Modern information and communication technology”. Relatively few innovative solutions were identified for food safety, hygiene aspects, and regulatory issues.

It can be seen that the case studies used some innovation for each category. These are particularly valuable since they we all tested by the use of short food supply chains.

It can also be seen that a significant number of innovative solutions applicableto SFSCs were identified from additional sources.

In Figure 3., the proportion of relevant digital solutions is shown.

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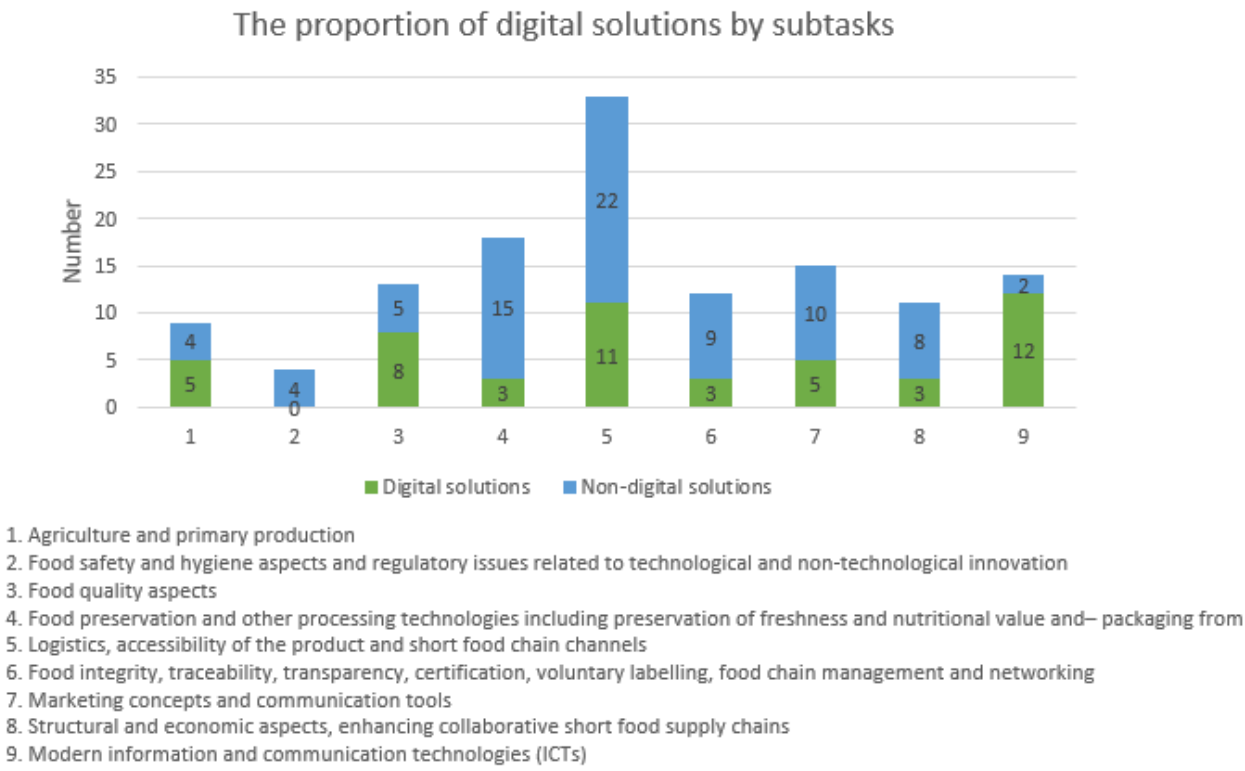

Figure 3.: The proportion of digital solutions by the different aspects

The solutions having some digital elements represent 38.6% of the innovations collected. They represent a significant part of the innovative solutions at agriculture and primary production (55.5%), at the food quality (61.5%), at the logistics (33.3%), at the marketing concepts and communication tools (33%).

the Figure 4. shows the distribution of the innovative solutions by categories of supply chain needs and short food chain supporting techniques.

It can be observed that a large number of solutions are available for improving the accessibility of product of SFSCs for consumers and access to markets and consumers for SFSC members, for storage, for quality, for food safety, sustainability, and trust, while a very limited number of solutions can be found for ethical aspects, increased negotiating power, access to infrastructure, a limited number for achieving fair price, product development support.

There are not any solutions identified for transport itself, however, a large number of solutions are available for logistics. No solutions are available for improving the policy environment and relatively few to assist compliancewith legal requirements.

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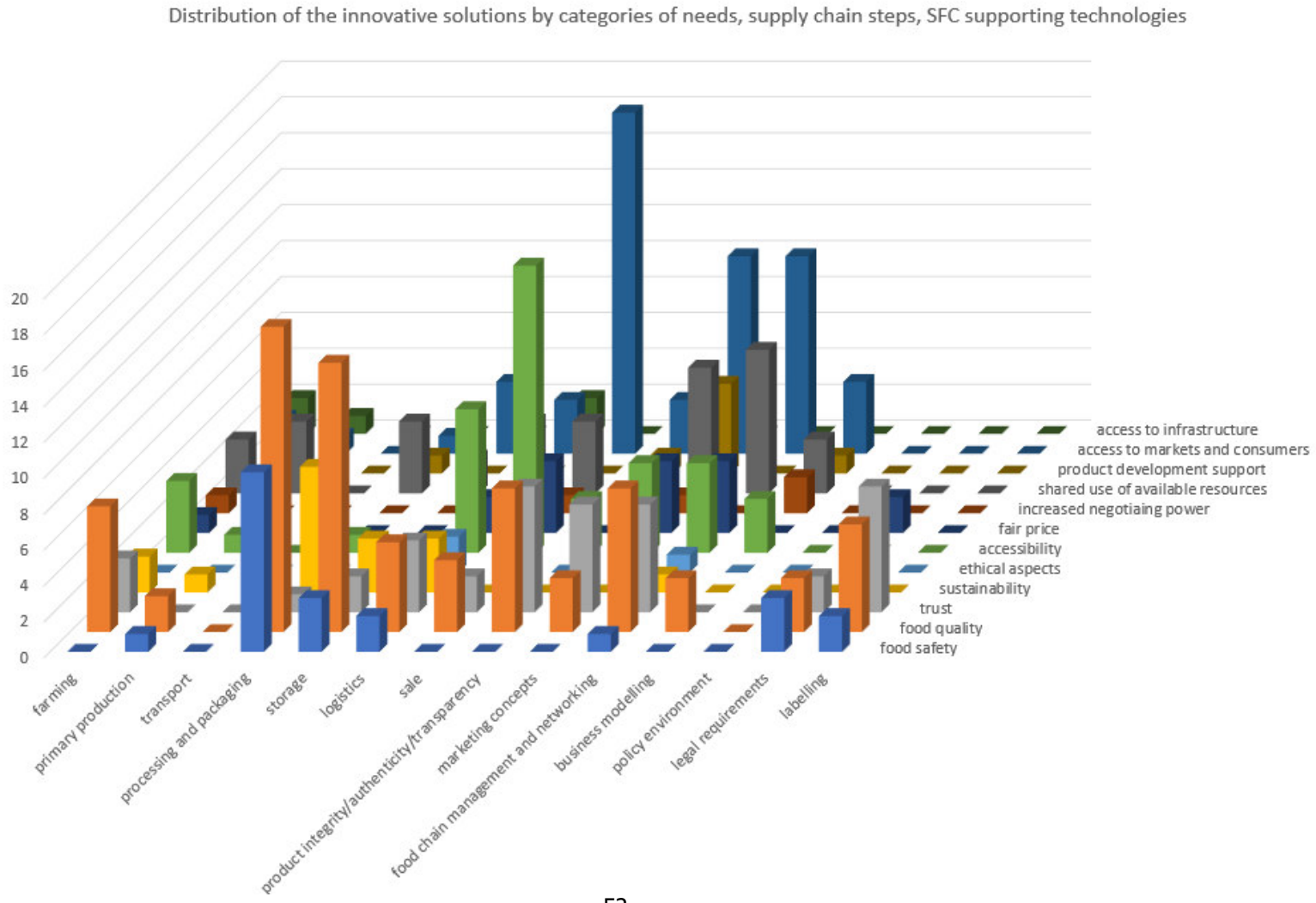

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Figure 4: Distribution of the innovative solutions by categories of needs, supply chain steps, short food chain supporting technologies

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Table 2: Innovations for different steps of the short food value chains

The step of the value chain	Applicable innovative technologies
Production	- organic - selection of a specific crop, breed fitting to the growing conditions, which has distinguishable with good sensory or nutritional property - smart (greenhouse monitoring system) - Good Agricultural Practices (GAP) guidelines - differentiation - own meteorological station for prediction of the optimal harvest date - traditional growing, breeding techniques
Primary processing	- sorting, size grading to improve the appearance - vacuum cooling (mobile) to remove field heat - hydro-cooling to remove field heat - modified atmosphere packaging - using freeze-dried or alive bacterial inoculum based on *Lactobacilli* to prevent spoilage - mobile juice press animal keeping settlements (mobile slaughterhouse, automatic milking, and grazing) - automation - robotic graders - carcass cutting service by municipalities
Food processing	- pasteuriation, - minimal processing technologies - sous -vide (food safety competence is needed) - High Hydrostatic Pressure - ultrasound for homogenisation - ultrasound for meat curing

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	- cryogenic freezing - freeze-drying - vacuum microwave drying - cutting by ultrasound (tuna) - sorting fish (Mackerel) by an automated colorimetric sensor system - extrusion - standard quality – develop specifications, emphasizing product benefits, using rapid tests for sugar, nitrate content, etc. - use of simple preserving, processing technologies. jam making, cheese making, sausage making, butchery, bakery, savory sauces and relishes, dried fruits – on-farmm processing - craft brewery with subcontracted brewing
Food packaging	- home compostable, biodegradable - made of plant material (green packaging, UHOH) - disinfection of air at the packaging - biodegradable packaging with natural indicator substances (curcumin) - all-in-one packaging
Food safety and food quality measurements	- nline prediction of food quality, food safety and shelf life - ultrasound for meat quality prediction - biosensor system as an indicator of harmful microorganisms - detection of foreign bodies (NIR, Hyperspectral imaging) - evaluating effective - lyophilized or alive - microorganisms against fungal contamination (UNIBO) - rapid testing methods
Logistics	- control of the cold chain (time, temperature) -data logging to monitor food safety, shelf life, transparency to increase consumer's trust

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	- route planning - electronic sealing - traceable crates for fresh produce - predictive analytics of the orders, needs - application of smart technologies
Last-mile delivery	- Online sales (applications, websites) - On-farm sales: - farm shops - farm restaurants - farm hotel catering - Off-farm sales - Home delivery - Vending machines with temperature control if it is needed (pick up points, smart lockers) - delivery schemes (boxes, lunch boxes) - collective sales to institutional catering, restaurants - local shops supplied directly - regional corners in the supermarkets - Direct sales: - Community Supported Agriculture (CSA) - farmers markets, organic markets, local markets - producer's shop - multi-channel sale - demand-driven supply chain - post office delivery - HORECA services
Compliance to legal requirements	- Model HACCP Schemes, Generic HACCP Models

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	- Good practice guidelines, HACCP and hygiene, Good Agricultural Practice - Validation by international certification bodies - Education
Marketing and value chain strategy concepts	Since the volume is limited DIFFERENTIATION should be followed instead of price competition! VALUE FOR MONEY shall be the value proposition! “Be different, be better” – Baxters Kitchen In the brand and market building phase focus on Business to Consumers (B2C) channels instead of B2B with retailers
Flexibility and adjustment of the implemented methods to the specific local ecosystem	- Branding and easily recognizable logo, trademark built on voluntary standards (AGPFGA) - Umbrella brand - Identity through certification, PDO, PGI, TSG, mass balance supported by satellite systems and drones - Animal identification through integrated ENAR-code - Farm visits, tours, open farms, pet zoo, festivals, events where producers and consumers can meet - Webd-based transparency videos - Selling local products in the farm shop – diversity of local (traditional) products, a collaboration of several farmers, sales communities, an umbrella brand - Elongation of the season with different varieties having different harvest time - Increase diversity with different varieties having a different color, taste shape - Increase the choice of products, product line extension - Increase the image of high quality (do not afraid of premium price), - collections, “signature range”, individual numbers, quality category range like Port Wine

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	- Recipe cards (AGPFA) - "Pick yourself" – "Pick, Drive, Deliver" - Develop consistent messages along with the value propositions - Define your consumer segment(s) precisely - A fixed price for a period, annual contract - The rolling average price of 5 years period - Delivery of local products (specific premium quality to restaurants) - Establishing different restaurants to different customer segments at touristic places (Bluefish) - Delivery of boxes of ingredients for meals with recipes – collected from several local farms - Social farming with underprivileged people - Storytelling (Scottish jam/ Baxters Kitchen, distilleries, etc) - Consumery-friendly labeling - Education at schools - with public support and public programs to collect traditional products as a part of the cultural heritage - lead user approach - social media marketing - crowdfunding - CleanHealth environment - Valorization of the out of specification by processing fruit juice, jams
Collaboration and value chain management skills	- method for identification of chain objectives representing mutual interests of all members of the chain (TRUFOOD, CAPINFOOD) - Training (Training material – TRUEFOOD, CAPINFOOD, SALSA) - Public support/ co-funding of the initial phase of collaborations - Public support/ co-funding of demonstration of adaptations of technology solutions - Link with publicly funded R+I projects to participate in the exploitation of

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	their results – for niche markets - online platforms

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5. Value propositions

General value propositions were developed by considering the typical operating conditions of SFSCs for each main driver of innovation of food chains related to consumer expectations from the Campden BRI needs document (Campden BRI, 2018). These can be used for building competitive advantage of SFSCs. The operation of the SFSCs was reviewed and re-designed in the light of supporting these value propositions by using a value chain management approach built on exploiting complementary resources, capabilities, competencies of value chain members (Gellynck et al, 2006). Specific attention was paid to the potential application of new enablers provided by digital technologies.

It can be established that for the majority of the SFSCs a value for money strategy can be feasible, based on differentiation.

The following general value propositions based on technological and non-technological aspects associated with the short food chains can be provided:

1. Genuine, authentic, non-manipulated, protected with particular care from (chemical) contaminations associated with the global food supply, organic, transparent, not adulterated– *Food safety*. *From a safe, assured source.*
2. Fresh, tasty, natural, specific high quality, distinguishable, produced/processed in a responsible way – *Food quality and value*
3. Fresh, high nutritional value, natural – *Nutrition, health, and well-being*
4. Less transport and distribution, local supply, less Greenhouse Gas (GHG) emissions, less distribution cost, the fairer price for producers, social responsibility in food production (less use of chemicals, less environmental impact from technologies, no GMO) and in employing underprivileged, disabled people, consumer empowerment – *Sustainability, resilience and food security*
5. A potential place to learn about food production, about nature, place to educate children through playing – *Skills and knowledge*

These can be used as a starting point for developing the value proposition for a specific chain.

6. Conclusions

The inventories of the needs and the innovative solutions can be analyzed in the future for identification of the gapsin the availability of innovative solutions for the specific needs of the SFSCs. The result of this analysis can be used as an input for the identification of the typical bottlenecks and potential success factors of the SFSCs.

From the preliminary analysis, it can already be identified that a typical weakness is the low willingness of the chain members for collaboration.

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An other typical weakness is the limited use of the marketing knowledge – e.g. many chains are complaining about their vulnerability in price competition, but limited efforts are paid to a "value for money" approach based on clear differentiation from the conventional, long global chains.

Digital solutions can provide significant support for SFSCs for improving the performance of the operation. There is a need for a systematic review of the activities of the SFSCs for identification of the opportunities for application of digital solutions.

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The current inventory of the needs, the current identified and collected 129 innovative solutions, and the analysis tool for matching the needs and the related innovative solutions will be soon available in the innovation inventory on the SMARTCHAIN innovation platform (https://www.smartchain-platform.eu/).

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