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RESEARCH ARTICLE

Suitability of Active and Intelligent Packaging for Local and Organic Food: A Case Study in Southern Finland

Sara Paunonen*
VTT Technical Research Institute of Finland Ltd

Marja Pitkänen
VTT Technical Research Institute of Finland Ltd

Ville Leminen
Lappeenranta University of Technology

Mika Kainusalmi
Lappeenranta University of Technology

Mika Vähä-Nissi
VTT Technical Research Institute of Finland Ltd

ABSTRACT

This study explores the suitability of innovative packaging for local and organic food. Attitudes and opinions in local and organic food chains in Southern Finland were collected via eighteen semi-structural interviews. The respondents were small-scale producers and processors of fish, meat, berries, and mushrooms, wholesalers, retailers, and institutional kitchens. The aim of this study was to understand factors promoting and preventing the penetration of innovative packaging solutions into the organic and local food market. A clear majority (86%) of respondents considered active and intelligent solutions to be equally suitable for local and organic food as for conventional food. However, less than half would actually use the technologies in their own products.

KEY WORDS

Local and organic food, food supply chain, packaging, active and intelligent packaging, interview.

***Sara Paunonen**
Corresponding Author
sara.paunonen@vtt.fi

INTRODUCTION

Active and intelligent packaging is a well-established term for a subgroup of advanced packaging technologies [6][7][10][11][12]. Active packaging extends the shelf life of the product by interacting with the consumables inside the packaging. It exhibits, e.g., moisture control, oxygen scavenging, ultraviolet ray blocking, antimicrobial or antioxidant properties [9][10][11]. Active packaging can be divided into systems that either absorb unwanted or release active substances. Intelligent packaging solutions monitor the freshness and quality of the food product during transport and storage using time/temperature indicators, gas detectors and freshness and ripening indicators [10]. Intelligent packaging also comprises solutions for tamper-proofing, theft detection and product authentication [6].

Active and intelligent is a rich field of technologies, some of which, such as moisture absorbers or oxygen scavengers, have a stabilized role in the consumer goods market, while some other, such as antimicrobial materials or indicator solutions, are still evolving from introduction into commercial success [9]. It has been estimated that fewer than 10% of patented packaging inventions are actually exploited and introduced into the market [8].

Sales of organic food have increased in the EU in recent years together with consumers' interest in organic and local food [1][2]. The motives to buy organic usually include health and nutritional aspects, superior taste, concern for the environment and animal welfare, food safety, support the local economy, or curiosity in a fashionable trend [23]. Local food is produced, processed and retailed within a defined geographical area, but it is not a clearly defined concept or market sector [37]. Motives to buy local include perceived freshness and quality of the food, support for the local economy, and low environmental impact [24].

The objective of the present study was to determine whether one specific niche food market, local and organic food, would present a future market for active and intelligent technologies, and whether the ideologies of organic and local pose any hindrances to adopting such technologies. The buying motives related to organic and local food, such as health, and low environmental impact, are potentially in contrast to technology-assisted shelf-life extension via active and intelligent packaging technologies.

The factors driving packaging development can be divided into four groups: business dynamics (companies, technology development, prices), distribution and retail (globalization, logistics, automation), consumption (geography, demographic development, consumption habits), and legislation (health and safety, environment) [34][35]. Each packaging innovation emerges from a mixture of these factors, but identification of opportunities is difficult [36]. At a practical level, critical aspects regarding commercialization include the cost of the technology compared to the assumed benefits, reliability and complexity of the technology, environmental-friendliness of the solutions, issues with the supporting regulatory framework (such as the EU regulation on active and intelligent materials), and consumer acceptance of the new packaging system [6][7][11].

From this pool of factors, our aim was to focus on value chain stakeholders and their readiness to exploit a given technology. Value chain stakeholders have a double role as professional decision-makers and actors that bring products to the market, but also act as consumers. We assume that these roles are mixed in the informants' responses.

Active and intelligent packaging is generally positively received by consumers [13][14][15][17][18], potentially because the benefits that advanced packaging solutions offer are aligned with consumer preferences and priorities [13]. Previous published studies have mainly focused on consumer

acceptance of time-temperature indicators (TTIs) [14][18][19], oxygen absorbers and scavengers [13], freshness indicators and leakage indicators [13][14], and recently on the consumer acceptance of nanotechnology in food packaging [20][21][22]. In a study by Smolander et al [14], 60% to 80% of consumers and retailers considered TTIs and freshness leakage indicators as desirable features in packaging. The benefits were mainly associated with product safety. The top two main restrictive factors are more than adequate current solutions and price of the solution, according to brand owners and packaging converters [16].

Based on the literature, we assert that local and organic value chain members do recognize the benefits of active and intelligent packaging technologies. The goal of the study is to explore if the of organic and local ideology as perceived by the value chain stakeholders is in conflict with active and intelligent packaging.

METHODS

Meat, fish, berries and mushroom food chains in Southern Finland were chosen for this study. These food groups were seen as having export potential. Table 1 shows the numbers of local food processors in the regions comprising Southern Finland. The clear majority of the businesses are small, having less than 5 employees, in all the regions. The table also shows the total number of organic food processors in these food chains.

Relevant food chain actors were invited through the local food web site [38] and organic and local food fairs. Some actors were already cooperation partners, and some recommendations from the other interviewees.

This study is based on semi-structured interviews of 18 mainly micro- (less than ten employees) and small-size (less than 50 employees) companies along the supply chain. Three of the food producers and processors are in the organic food business, and the rest in the local food business.

Table 1: Number of local and organic food processors by region in Southern Finland. Data for local food from [38], for organic food from [39].

	Local food processors (currently, 2018)				Organic food processors (in 2016)
Region in Southern Finland	**Meat [nbr]**	**Fish [nbr]**	**Berries, vegetables, fruits [nbr]**	**Less than 5 employees in company [%]**	**All food chains [nbr]**
Northern Carelia	13	16	18	76	20
Päijänne Tavastia	13	2	16	73	58
Satakunta Region	40	37	65	82	22
Southern Carelia	19	14	39	85	--
Southern Savonia	23	10	16	75	15
Southwest Finland	41	40	49	67	50
Uusimaa Region	29	17	18	58	120

Table 2: Site characteristics and role of the informant in company.

ID	Additional roles	Organic or local food	Food products	Company size*	Location	Informant
PRODUCERS						
Pd1	—	Local	Berries	Micro	Northern Carelia	Owner
Pd2	Processing & sales	Organic	Berries and mushrooms	Micro	Southwest Finland	Owner
Pd3	—	Organic	Mushrooms	Medium	Satakunta Region	Sales Manager
Pd4	Processing	Local	Meat	Micro	Southern Carelia	Owner
Pd5	Processing	Organic	Meat	Micro	Uusimaa Region	Owner, CEO
Pd6	—	Local	Fish	Micro	Southern Carelia	Owner
PROCESSORS						
Pc1	—	Local, Organic	Berries and mushrooms	Small	Southern Carelia	Operative Manager
Pc2	—	Local	Berries	Small	Southwest Finland	Quality Engineer
Pc3	—	Local	Fish	Small	Southwest Finland	Mill Manager
Pc4	—	Organic	Meat	Medium	Uusimaa Region	Product manager
WHOLESALER						
W1	—	Organic, Local, Conventional	All	Micro	Päijänne Tavastia	CEO
W2	—	Local, Organic, Conventional	Vegetables	Micro	Southwest Finland	Owner
RETAILER						
R1	—	Organic, Local, Conventional	Selected, including meat, fish	Micro	Southern Savonia	CEO
R2	—	Organic, Local, Conventional	All	Big	Southern Carelia	Sales Manager
R3	—	Organic, Local, Conventional	All	Big	Southern Carelia	Retailer
HORECA SECTOR						
H1	—	Organic, Local, Conventional	All	Big	Southern Carelia	Catering Manager
OTHER ACTORS						
O1	—	—	All	Micro	Southern Carelia	R&D Manager
O2	—	—	All	Micro	Northern Carelia	Owner

** EU classification of enterprise size based on number of employees and turnover: micro, small, medium, and big. See http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3An26026. Actors involved in organic food business.*

Other actors include two wholesalers, three retailers (one concentrating only on local and organic foods), an institutional kitchen in the horeca sector (hotels, restaurants and cafes), a logistics entrepreneur, and a research and development entrepreneur. The informants are described in Table 2.

The interviews were carried out during the fall 2015 by a Master student. A list of open preselected questions was interactively discussed with the informants. The questions were divided into two sections: views and opinions on the future of local and organic food business in Finland, and views on advanced packaging solutions. The interview questions are listed in Table 3. The same question set was used for all the interviewees, irrespective of food chain.

When moving to the question set B, an introductory text was read to all informants, mentioning the following active and intelligent packaging solutions: oxygen scavengers, antimicrobial packaging materials, time-temperature indicators, leakage indicators, and freshness indicators. The texts were retrieved from [25]. This was done to introduce the topic of the interview and to prime the respondents.

The interviews were recorded and transcribed by the interviewer. To facilitate data handling and analysis, the profile of each response was summarized in a table by extracting keywords and short sentences that captured the main information content of the informant's reply. This condensation of data and the subsequent analysis were performed by the authors, who are packaging material researchers. Frequencies of how often a topic was mentioned by the respondents were calculated. Descriptive answers to themes A and B were then constructed based on the topics that were most often mentioned. Arguments for and against the topics were also searched for and included in the descriptive answer. The answer to the research question was retrieved based on quantitative analysis, by counting categorized answers.

RESULTS

Future of Local and Organic Food in Finland

Sixteen of the 18 respondents anticipated that the future for both local and organic food is bright, although progress so far has been quite slow (Pc1; Pd2,5; Pc4). *"Five years ago I was sure that it [organic food] will easily get the upper hand, the same applies to local production. It doesn't seem to happen (Pc1)".*

Both markets are thus expected to grow, but the local food sector is expected to grow faster than organic food (Pd3,4; Pc1,3; R3). According to one producer (Pd3), people are local by nature and it is therefore

Table 3: The interview questions.

THEME	QUESTIONS
A. Future of local & organic food business	1. How do you see the future of the local and organic food market in Finland? 2. How do you think consumer attitudes and their buying potential will change? 3. How will sales channels change? 4. How will the evolving local and organic food business affect packaging?
B. Active and intelligent packaging solutions	5. Have you heard of active and intelligent packaging? 7. What do you think of such features? 6. In your opinion, would active and intelligent packaging be suitable for organic and local food? 7. Do you see any need for active or intelligent features in your own product packaging? Why/why not? 8. How much could active and intelligent features add to the cost of packaging?

natural to prefer local products. According to one processor, *"local is experiencing a boom at the moment (Pc3)"*. One producer (Pd1) considered the local food sector to be less affected than organic by the state of the domestic economy. Organic, on the other hand, is an ideology that the consumer has to actively embrace (Pd3). The group of organic consumers was considered small but stable (R3). Another limiting factor is that Finnish consumers traditionally consider conventional domestic food production to be pure and relatively free of chemicals (Pd2; Pc1), leading to a lack of drive to adopt alternative food trends.

According to stakeholders throughout the supply chain, product price is the strongest and decisive factor for both consumers and institutional buyers (Pc1; W1,2; H1; R3). *"The majority of consumers are only looking at price, and don't care if the content is life threatening (Pc1)"*. A wholesaler (W2) added that *"Over 20 years we have been talking about this [organic], but when it comes down to purchasing, the cheapest product is wanted, and cheap is always asked for (W2)"*. The same applies to local food, as *"our buying clients never ask whether a carrot is grown in Joutseno [the neighboring town] or in the Netherlands (W2)"*.

The increasing demand for local and organic food is being driven by changes in consumer attitudes. Consumers were considered to be becoming more and more aware, informed, and interested in what they eat (Pd2,5,6; Pc2; R1; O1), especially younger generations (Pd4). *"Some are forced to do that [become interested in what they eat], because they have gotten ill (H1)"*. They may even become skeptical about exported food products (Pd6).

Sales and delivery of local and organic food were estimated to become more diversified (Pd2,5; Pc1,2; R1,2; H1; O1). Several producers and processors mentioned REKO rings and food circles as new and alternative channels for selling and distributing food to consumers directly (Pd1,4,5; Pc1,2; H1). One producer was participating in a REKO ring (Pd4). The word REKO comes from the Swedish word for fair consumption (rejäl konsumtion), although this business model has its origin in Finland [26] [27]. In the REKO model, producers and consumers meet and agree on the details of sales in administered closed groups via social media. The delivery of goods and payment occurs in regular gatherings.

In spite of new delivery channels, the role of centralized retailers remains compelling (Pd1; Pc3,4) and the growth of local and organic is likely to remain limited as long as retailers remain distanced from these ideological movements (Pd1). Retailers are powerful actors in the food chain, and their attitudes strongly affect the need to seek alternative sales channels (Pd2). One producer commented that centralized distribution is needed, as small-scale distribution is costly and laborious for small producers (Pd6). Internet sales will probably grow (Pd3,5; R1,2,3), but this is not a very attractive option (Pd3,4,5,6; Pc4; H1) especially for fresh products (Pc3).

Two producers (Pd3,6) mentioned that innovative packaging trends are normally applied within the local and organic food sectors. However, the direction of influence was seen in some instances to run the other way, with the conventional food sector asserting pressure towards the development of new packaging solutions. One such instance is the need to develop ecological packaging (Pc2,3; Pd3,4; R1,2; O1,2). Here, the choice of sales channel and extent of transport are the key factors affecting the packaging format and size (Pd5; R3).

The ideologies of local and organic could foster a movement towards sales of loose goods and multi-use packaging instead of buying products in single-use packages (W1; H1). The local and organic sectors will not generally be at the forefront of adopting the latest packaging innovations (Pd1).

Active and Intelligent Packaging

Awareness of active and intelligent packaging technologies and their experienced desirability.

Two (O1,2) out of the 18 interviewees did not give any response to this question. Eleven of the remaining 16 respondents had heard or knew about active and intelligent packaging solutions. Five of them clearly had no previous knowledge. After listening to the introduction, nine respondents mentioned that they consider active and intelligent solutions to be a positive development. *"Of course these are welcome (R3)"*. It was considered that these solutions can only improve packaging, not worsen it (O2). In addition, *"Dumb packaging is not worth doing (O2)"*. Use of these solutions was expected to increase in the future (Pd6; Pc2,4).

Antimicrobial materials have the potential to revolutionize the shelf life of delicate foods and thus the logistics and distribution of food (Pd1; Pc2; R3). Freshness and quality sensors (Pd2, 6; O1; Pc3, 4), sensors for package integrity (Pc4), and time-temperature loggers (Pc2) were also considered beneficial features. These technologies are especially suitable for fresh products (Pd1; R2), meat and ready meals (Pd4). However, the promise that these solutions claim to deliver is easily made empty if the cost is too high (Pd1; R3; H1; O1).

Three respondents expressed a clearly negative stance towards the technologies, which they saw as empty gimmicks with no actual need or value driving them (W1). The most common objection was that people should use their own senses to detect spoiled food (Pd2,3, W1, R1) and that there is no need for additional devices. However, other actors did not share this view, stating, for example, that *"They [the solutions] don't erase the need for sensory or visual evaluation of the food product (R3)"*. One informant considered the technological developments as causing people to think less for themselves and even as a frightening development (R1).

Five stakeholders were ambivalent or simply stated that this is the trend irrespective of peoples' needs and opinions (Pd4,6; R2, H1). The technologies were also expected by one respondent to be in common use within 5 to 10 years, but their time had not come yet (Pd6). Some had doubts about the reliability of the technologies (Pd4) or suspected that they could become compulsory against the wishes of the food chain stakeholders (Pd2).

Experienced suitability for local and organic food

Four (Pd2,6; W1; R1) out of the 18 interviewees did not give any response to this question. Twelve of the remaining 14 respondents said that active and intelligent packaging technologies would be equally suitable for local and organic food products as for conventional products; many of them even added the rhetorical question *"Why wouldn't they be?"* Organic food was actually seen to benefit more from these solutions than conventional food due to the challenges in maintaining its quality (Pc1; R3; O1) and higher engagement among organic shoppers (Pd5). However, it was also stated that if the food chain is shorter or faster, or does not include centralized warehouses, there would be no need for the mentioned technologies (Pd1,3). One actor was positive towards the development, but anticipated that nobody in the local and organic food chain would be willing or able to pay for it (W2).

Only two of the 14 preferred not to have these technologies in local and organic food packages. The technologies were not seen as necessary or even ecological (R2), or that organic and local food should be consumed so soon that there is no need for them (H1).

Active or intelligent features in own product packaging

Four (Pd2; W1; O1,2) interviewees did not give any response. Nine of the remaining 14 respondents stated that they would use active and intelligent packaging solutions for some of their own food products, and 5 of the 14 would not. The lucrative use cases that were mentioned included an oxygen scavenger for export of organic berries (Pc1), a tool for monitoring the integrity of pasteurization (Pc2), and a quality indicator for fresh products, especially meat, and processed meat products such as sausages (R2,3). Two producers thought that time-temperature logging and cold chain integrity monitoring would free them from responsibility and place all competitors on a level playing field as long as all actors adopted the system (Pd3,6).

The main obstacles to using advanced technologies in the informants' own products included price (Pd3; Pc2,3; W2; R1; O2), lack of proven added value (Pd5; Pc2; R2; H1), technical complexity and lack of robustness of the solution (Pd1,4; Pc4; R2), and the consequent amount of labor and maintenance needed (Pd1). In addition, liability issues in the event of deviations (Pd5), current packaging machinery not enabling their use (Pc1), and increased risk of misconduct (Pd1) were also mentioned. One producer stated that *"it's annoying if every package has to something to say (Pd1)"*. However, some actors stated that there are no valid reasons for not using such advanced solutions (Pd6; O1).

Color indication or similar would be the favored reader technology (Pd1,3; Pc1,2,3,4; W1; R1,2,3; H1), especially for consumer applications, as no separate devices are needed and the reading is easy. On the other hand, use of the mobile phone as a reading device was also supported (Pd2,4,5; Pc4; W2). It was considered that loggers and reader devices could be used by workers in the industry and supermarkets (Pd1,4; Pc2,3; R2). One retailer described a potential IoP (Internet of Packaging) scenario where the sensors would send data to the cloud (R3).

Maximum desirable cost increase

When asked about how much the advanced features might increase the cost of packaging, answers ranged from zero or very little (Pc4; R1,2; H1), to some, approximately 10% to 20% (Pc1,2), up to even 400% (5-fold price) (R1). One retailer (R1) considered the price of packaging to be so low that the new technologies would be a considerable cost addition, whereas a producer considered packaging to be a major expense for farms already as it is (Pd1).

Several respondents emphasized that it is the advantages achieved by the technologies that are ultimately decisive, not their cost (Pd1,4,5; Pc1,2; W1). If a feature is not useful or appealing to the consumer, the cost increase is not justified (Pd4; Pc1). A cost increase due to break-through packaging technology was also considered acceptable (Pd5), but small producers would not be the first to adopt them (Pd5).

DISCUSSION

There is a consensus that active and intelligent packaging techniques do possess considerable potential to improve the safety, quality and traceability of food products, as well as convenience for consumers [7]. According to our results, this applies also to local and organic food.

The majority of the respondents, 86%, held a general positive attitude towards active and intelligent packaging technologies, and thought that they are equally suitable for local and organic food as for conventional food. This is in line with previous results on positive attitudes of consumers [13][18] and retailers [14] towards intelligent packaging. Smolander [14] reported that 80% of interviewed Finnish retailers had a positive attitude towards intelligent packaging systems such as time-temperature, freshness and leakage indicators intended for retailers' own use in product quality and safety management. According to Pennanen [18], Finnish consumers were positive towards intelligent packaging

solutions for their own and retailers' use, but less so than in the other European countries studied.

Local and organic ideologies are not in conflict with intelligent packaging technologies. Three respondents actually emphasized that especially active packaging solutions would be beneficial for organic food. Antimicrobial materials were even considered to possess the potential to revolutionize the logistics and distribution of delicate foods by extending shelf life. Intelligent packaging systems were not so clearly supported.

In the EU, organic food is produced without potentially harmful preservatives and restricted use of food additives in compliance with Council Regulation (EC) No. 834/2007. In conventional food these chemicals are used to prevent microbiological spoilage and thus prolong shelf life, which makes shipments over distances and export possible [33]. Varying results have been reported on how organic food stores and consumers perceive shelf life, although the shelf life of organic food is generally considered shorter [33]. However, some reports propose that organic food actually has a longer shelf life than conventional food due to, for example, high levels of antioxidants [29].

The possibility to prolong the short effective shelf life of organic food in supermarkets is a clear incentive for the use of advanced packaging. Studies have shown that organic products generate a higher level of waste in supermarkets compared to their conventional counterparts [28]. Shelf life may be equally long for organic and conventional product variants, but due to low sales volumes and slow inventory turnover, the effective shelf life of organics is too short, leading to high wastage [28].

Only a small number of respondents, 14%, held a clearly negative general attitude towards advanced technologies, due to, e,g., fear towards outsourcing responsibility from people to devices. In total, 40% of the respondents would not use the technology in their own products due to a range of reasons, such as price increase, lack of added value, and possible technical complexity. Local and organic producers and processors have limited resources and interest in being the first adopters of new packaging technologies, especially if the benefit is debatable. The only exception was sustainable packaging, where these actors could actually lead the way. Factors such as increased food loss or difficulties of interpreting the indicator results [18] were not spontaneously mentioned as disadvantages of intelligent technologies by the respondents of this study.

In 2015 the organic food market in Finland was valued at EUR 240 million, which is about 1.8% of the total food market. The annual growth in the organic food market was almost 7% in 2015 [3]. The methods for evaluating the local food market size, and their results, vary. The size of Finland's local food market was EUR 962 million in 2012 [4]. These markets, currently still relatively small, are movements that are changing the food market.

Almost all (90%) of the respondents expected growth both in local and organic markets. However, the organic food market was seen to grow at a slower rate than local food. In the long run, a widening market would bring motivation and possibilities for producers and processors to improve packaging. The respondents considered younger generations as potentially more interested in using advanced packaging technologies and more willing to pay for them than older generations. Research results [30] and every-day stereotypes support the fact that younger generations are indeed faster to accept new technologies and integrate them into their lives. However, older generations would actually benefit more from the advanced technologies [18].

Organic food products are more expensive than conventional food due to higher costs of production and environmental enhancement and animal welfare costs. Smaller volumes lead to accumulation of costs from handling, processing, distribution, marketing and lead to generally poor economy of scale [33]. The extra cost of advanced packaging features on top of a more expensive food product and its basic packaging poses a considerable push factor against, or at least a challenge for, the wide deployment of advanced solutions.

According to one small-scale producer, *"It is well accepted that packaging has a role – and a cost".* The informants described the amount of cost in several ways. Packaging was said to increase the price at farms by a few percent per kilogram of product (Pd5), representing approximately 10% of purchases at the farm (Pd1), or an additional cost of about 1 euro per piece (Pd3). Almost a third (30%) of respondents considered the potential benefits of advanced packaging to be more decisive than cost.

The uptake of advanced packaging technologies varies by application and market area. As an example, global revenue from active food packaging was relatively stable at $8.0 billion in 2014, and $8.3 billion in 2015 according to BBC Research [31]. Antimicrobial agents and packaging, moisture controllers, and ethylene absorbers are the top three segments behind these figures. In the US, Japan, and Australia these technologies are already applied successfully, whereas in Europe progress has been slow [32].

In our sample, 30% of respondents representing Southern Finnish local and organic food chain actors had never heard of these technologies, and none of them used one. According to our results, there should be no principal obstacles for application of active and intelligent packaging technologies in the future, as the general attitude of the stakeholders is clearly positive, the usefulness of active and intelligent packaging technologies is acknowledged, and reasonable cost increase is accepted.

LIMITATIONS

As the sample size of our study was limited, the results are indicative and cannot be generalized to consider the organic and local food chain stakeholders in Southern Finland. However, the clear majority of stakeholders that were interviewed did consider active and intelligent packaging techniques to be equally suitable for local and organic, as for conventional food. The interviewer was not trained to carry out interviews. As the questions were simply read to the informants, the potential bias introduced by the interviewer can be considered as relatively small. However, the introductory text that was read to all informants probably introduced some bias to the results. When formulating their answers, the informants had these examples in mind.

CONCLUSION

A clear majority (86%) of the respondents of this study considered active and intelligent packaging techniques to be equally suitable for local and organic food as for conventional food.

Technologies prolonging the shelf life of delicate foods and organic products were seen as the most desirable.

However, less than half would use the technologies in their own products. The most commonly stated reasons for this were price increase, lack of proven value added, and technical complexity.

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