



Analysis of the contribution of Liuzhou's local specialty food (Liuzhou Luosifen) policy to regional economic development

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Abstract

The city of Liuzhou, China, has developed a local specialty food policy since 2016 which today is considered one of the most successful local food policies in China and a best practice at international level. Liuzhou Luosifen (Liuzhou snail rice noodle), a famous traditional Chinese snack, boasts a unique combination of sour, spicy, fresh and fragrant flavors. In 2022, the pre-packaged Liuzhou Luosifen sales revenue reached 18.2 billion yuan, exported to 28 countries and regions. The purpose of this study is to analyze the contribution of Liuzhou local characteristic food policy implementation process on the regional economy. The review highlights key information on the product background, the policy formulation, the industrial standardization, and the policy implementation. The social groups and leading enterprises have been important drivers of the product standards and formulation of the policy, while the processing and transportation flow of standardized products, are essential for the integration of regional economies (tourism, production, transport, marketing, etc.). Although the specialty food industry chain has comprehensively driven the development of the regional economy, it is still necessary to carefully consider the joint development of new markets and new social practices.

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Introduction

Liuzhou Luosifen, also known as Liuzhou snail rice noodle (Fig. 1), is a traditional Chinese specialty food renowned for its unique combination of sour, spicy, fresh and fragrant flavors^[1]. Liuzhou Luosifen is a staple food made with snail soup, rice noodles, and specific ingredients (pickled bamboo shoots, fresh green vegetables, sour string bean, etc.), which are rich in nutrients such as vitamin C, sodium, potassium, and more due to the abundance of raw materials. The diverse ingredients give it a unique and rich flavor, making Liuzhou Luosifen a beloved dish worldwide.

The 2012 Chinese food documentary 'China on the Tongue' first showed Liuzhou Luosifen to the national audience in an all-round way, and later became popular worldwide. CNN Travel once reported on Luosifen under the title 'How the 'durian of soup' became the hippest dish in China'^[2]. Liuzhou, the birthplace of Luosifen, has become one of the largest Chinese snack industry bases. The local government has announced that in 2022, the sales revenue of pre-packaged Liuzhou Luosifen reached 18.2 billion yuan, a year-on-year increase of 19.6%. The annual delivery volume exceeded 100 million yuan, and exports reached 83 million yuan, a 61% increase. The popularity of Liuzhou Luosifen has spread across 28 countries and regions, creating a fan base for this unique snack.

With the support of the local government, companies and other relevant institutions, the development of the industrialization standard system for Liuzhou Luosifen has been largely

completed^[3]. The system covers from writing, raw materials selection, food production technology and cultural brand publicity and other aspects^[4]. The implementation of a perfect standard system has ensured the healthy development of the Luosifen industry in Liuzhou, leading to a steady improvement of the regional economy. Liuzhou's tourism, catering, logistics, and agriculture industries, among others, have gradually been stimulated by the rise of the Luosifen industry. This paper offers an overview of several key aspects related to Liuzhou Luosifen products. Specifically, it covers the composition of raw materials and flavor profiles, the development of an industrial standard system, as well as the current state of regional economic growth centered around Liuzhou Luosifen.

Background

Liuzhou Luosifen, a beloved dish in southern China, has a rich and intriguing origin story that has captivated foodies and historians alike^[1]. There are two main theories about the origin of Liuzhou Luosifen^[5].

The first is the 'historical record theory' which suggests that Liuzhou Luosifen originated from Liu Zongyuan, one of the Eight Great Masters in the Tang and Song dynasties. Legend has it that when Liu was demoted to Liuzhou, he was so depressed that his body wasted away. His chef Zhou Wanfu cooked a soup with star anise, basil, pickled bamboo shoots, bean curd skins and snails found near the Liujiang River, and made a dish. Liu's appetite increased after eating, and named it 'Liuzhou Luosifen'^[5].



Fig. 1 Liuzhou Luosifen and its raw materials display.

The second theory is the 'Native origin theory'. In the late 1970s, the Liuzhou folk trade began to revive, and night markets sprang up on the streets. The Gu Fu Street vegetable market gradually became the largest gathering place for wholesale Liuzhou snails, and with a large number of nearby workers, night markets also emerged. In Liuzhou, people have a habit of 'sucking vermicelli' and 'sucking snails'. Smart vendors were likely to add a spoonful of snail soup to the noodles, which gradually formed the embryonic form of Luosifen. Over time, the ingredients used in snail rice noodles became more diverse, and bean curd skins, green beans, pickled vegetables, and peanuts were added to the small bowl of noodles, forming the present-day shape of Liuzhou Luosifen^[5].

Definition of Liuzhou Luosifen

Liuzhou Luosifen (including boiled Luosifen and brewed Luosifen) is made primarily from independently packaged rice noodles (dry rice noodles or brewed rice noodles) and snail meat soup, along with additional ingredient packages including pepper oil, sour bamboo shoots, bean curd stick, peanuts, and more. The components are combined and packaged together, and consumed by boiling in water or by pouring boiling hot water ($\geq 85\text{ }^{\circ}\text{C}$) over the noodles^[4].

Flavor

The unique taste and flavor make Liuzhou Luosifen become a memorable food. In this rich taste, rice noodles and sour bamboo shoots occupy the dominant position, and snail soup provides basic flavor (Fig. 2). More information can be found in Supplemental Table S1.

Rice noodles are a common staple food, and factors influencing rice noodle qualities are various^[6]. For rice noodles of Liuzhou Luosifen, the different grinding methods (rice noodles prepared with wet-, dry- and semi-dry milled rice flours) used by different manufacturers will also greatly affect its flavor^[7]. Authentic rice noodle of Liuzhou Luosifen is dried rice noodle made of old rice^[8].

Known as the "soul of Liuzhou Luosifen", the sour bamboo shoots have attracted a large number of lovers with their

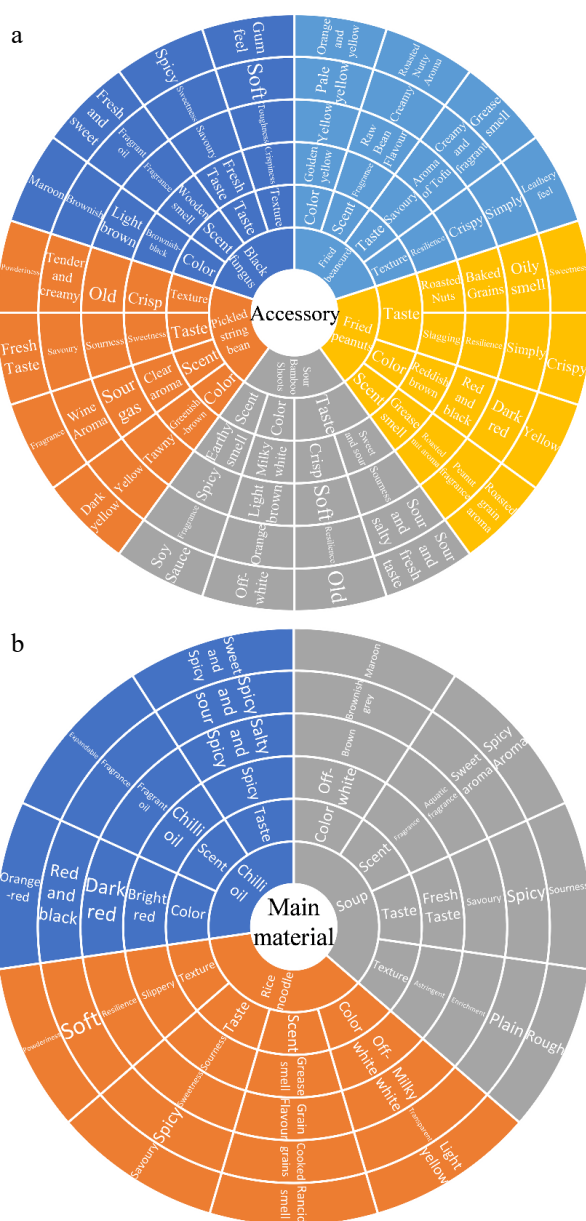


Fig. 2 Flavor wheel of each composition in Liuzhou Luosifen.

unique taste. In the traditional production process, sour bamboo shoots can be made by natural fermentation in brine with *Lactococcus* and *Lactobacillus*^[9]. During its fermentation, a large number of proteins decompose into amino acids and large amounts of sugars are converted into organic acids. Amino acids, organic acids and other components such as sugars and these sugars will further transform and react, producing a variety of aldehydes, acids, phenol, esters, alcohols and other substances (Table 1)^[9-11]. Among them, the hydrogen sulfide decomposed by cysteine and the fecal odor converted by tryptophan finally constitute the peculiar smell of acid bamboo shoots. During fermentation, fermentation strains can significantly affect product flavor^[12]. From the perspective of nutritional composition, sour bamboo shoots are a healthy food with low solid content, high water content, low sodium, low sugar, no fat, low calorie^[13].

Table 1. Flavor substances in sour bamboo shoots of Liuzhou Luosifen.

Category	Ingredient name
Alcohols	2-methylcyclopentanol, n-hexanol, 2-heptanol, 2-cetyl alcohol, cycloheptanol, cyclooctanol, 2,2-dimethyl-1-decanol pinanol, 2-(octadecyloxy) ethanol, etc.
Esters	2-bromo-2-ethylhexylpropionate, glycerol linolenate, methyl 9, 12-hexadecadienoate, ethyl caprylate, 10-methyl-8-tetradecene-1-ol acetate, ethyl benzoate, methyl 2-methylvalerate, ethyl phenylpropionate, 8-methylnonanoate, ethyl heptadecanoate, 3-(2-hydroxycyclopentene)-methyl 2-methylpropionate, ethyl palmitate, etc.
Amines	Dimethylamine, Etchamine.
Aldehydes	Hexanal, trans-2-heptenal, 2-bromo-octadecanal, trans-2-octenal, 2-tridecanal, nonanal, trans-2-nonenal, decanal, etc.
Ketones	4-methyl-6-phenyl tetrahydro-1,3-oxazine-2-thione, 1,7,7-trimethyl-bicyclo [2.2.1] heptane-2-thione, 2,5-heptanedione, damascone, etc.
Alkanes	Undecane, dodecane, 1-methoxyadamantane, tridecane, tetradecane, 7-hexylcycloalkane, 10-methyl eicosane, 3-ethyl-5-(2-ethylbutyl) octadecane, 2,6,10-trimethyl tetradecane, pentane, heptane, 1,3,5-triphenylcyclohexane, etc.
Alkenes	D-limonene, 2-isopropyl-5-methyl-9-methylene-bicyclo-1, decene, etc.
Acids	Acetonylmalonic acid, acetic acid, lactic acid, trans-13-octadecenoic acid, 9-hexadecenoic acid, etc.
Ethers	Dimethyl ether, octadecylvinyl ether, methylennonyl ether, etc.
Phenols	Phenol, p-cresol, 4-methoxyphenol, 2-methoxy-5-methylphenol, 4,4'-(p-phenylene) diisopropyl diphenol, etc.

Liuzhou Luosifen is called Liuzhou snail noodle because its soup is boiled with snail. The river snails used belong to the phylum Mollusca, *Gastropoda*, *Mesogastropoda*, *Viviparidae*, freshwater economic snails that mainly include the genera *Bellamyia* and *Cipangopaludina*^[14]. This soup is made of snail meat and dozens of natural spices (star anise, cinnamon, clove etc.), and the amount of these spices has a strict proportion. The selection of dual-use medicinal and food ingredients not only blends well with the freshness of snails, but also has certain health benefits^[15,16].

Nutrient value

Liuzhou Luosifen is a snack, providing the body with essential energy and the three main nutrients (protein, fat, and carbohydrates) needed for optimal health (Table 2). Side dishes like pickled bamboo shoots, black fungus, and fried beancurd also contain a plethora of vitamins and minerals, such as vitamin C, vitamin E, calcium, phosphorus, potassium, sodium, magnesium, iron, zinc, selenium, and copper, all of which are vital for the human body's optimal functioning^[9,17–20]. These minerals play an important role in the human body, such as calcium's role in developing the skeleton and iron's role in preventing anemia^[21]. Since the body cannot synthesize these mineral elements, consuming Luosifen occasionally and in moderation can help supplement them.

Application of analytical technologies

Regardless of the state of raw materials, the final product may be subject to biological, physical or chemical risks. National and international authorities, as well as food producers, focus on reducing or eliminating any potential harm to consumers. Therefore, the development and implementation

Table 2. Nutritional composition of prepackaged Liuzhou Luosifen.

Project	Nutrient composition	Content
Dry rice noodle (per 100 g)	Energy	351 kcal (1,468 kJ)
	Protein	6.2 g
	Fat	1.0 g
	Carbohydrate	78.0 g
	Sodium	6 mg
Seasoning packets (per 100 g)	Energy	213 kcal (893 kJ)
	Protein	5.2 g
	Fat	18.8 g
	Carbohydrate	6.6 g
	Sodium	1,800 mg

of comprehensive Liuzhou Luosifen testing technology is essential in improving food safety. Molecular spectroscopy technology, ion chromatography technology, real-time fluorescence PCR technology, and sensory analysis technology were used to detect Liuzhou Luosifen, respectively.

Qin et al. determined 12 elements in Liuzhou Luosifen by inductively coupled plasma mass spectrometry^[22]. Guo et al. have determined the volatiles in fermented bamboo shoots by Head Space – Solid-Phase Micro Extraction (HS-SPME) with Gas Chromatography – Olfactory – Mass Spectrometry (GC-O-MS) and Aroma Extract Dilution Analysis (AEDA)^[23]. Kong et al. have determined rapidly EDTA-2Na in prepackaged dried rice noodles by Surface Enhanced Raman Scattering Spectroscopy^[24]. Xie et al. detected found that Salmonella in pre-packaged Luosifen by Taqman real-time fluorescent PCR decreased the time to exclude negative samples from 5 d to 24 h, and saved the detection cost while improving the sensitivity^[25]. Qin et al. determined bongkreic acid in Liuzhou Luosifen by ultra performance liquid chromatography-tandem mass spectrometry^[26].

Industrialization standard system construction

The establishment of a food standard system is very important for the development of the food industry^[27,28]. Currently, there are more than 80 Chinese standards related to Luosifen food, which are from the aspects of raw material cultivation, production and operation, marketing and circulation, industrial park construction, brand creation and use, and management of trademarks (Table 3)^[4]. Corresponding requirements and regulations have been made for all links of the whole industrial chain of Liuzhou Luosifen, effectively ensuring the quality safety of Luosifen and the unique quality of 'Liuzhou flavor', which will further promote the standardization, branding, scale and digital developments of the whole industrial chain of Liuzhou Luosifen. Such a system addresses processing issues and enhances the quality and safety of the product.

Basic general-purpose and safety

In terms of basic general purpose and safety, its application scope and main contents include comprehensive foundation, food safety, food quality control management and traceability. Comprehensive foundation mainly refers to the terms, graphic symbols, classification and other standards related to Liuzhou

Table 3. The situation of whole industry chain standards on Liuzhou Luosifen.

Corresponding to the standard system	Project	Standard name	Reference
Basic versatility and security	Comprehensive foundation	GB/T 16900-2008 Rules for the presentation of graphical symbols-general principles	[31]
		GB/T 20000.3-2014 Guidelines for standardization-Part 3: Reference to documents	[32]
		GB/T 20001.10-2014 Rules for drafting standards-Part 10: Product standards	[33]
		GB/T 20002.3-2014 Drafting for special aspects in standards-Part 3: Addressing environmental issues in product standards	[34]
		GB/T 20001.3-2015 Rules for drafting standards-Part 3: Classification standards	[35]
		GB/T 20002.4-2015 Drafting for special aspects in standards-Part 4: Safety aspects for their inclusion in standards	[36]
		GB/T 13016-2018 Principles and requirements for constructing standard system	[37]
		GB/T 1.1-2020 Directives for standardization-Part 1: Rules for the structure and drafting of standardizing documents	[38]
	Food safety	T/LZLSF 0010.1-2022 Series products of pre-packaged Liuzhou Luosifen-Part 1: pre-packaged Liuzhou Luosifen of self-heating	[39]
		T/LZLSF 0010.2-2022 Series products of pre-packaged Liuzhou Luosifen-Part 2: Liuzhou river snail made with pot	[40]
		T/LZLSF 0010.3-2022 Series products of pre-packaged Liuzhou Luosifen-Part 3: Liuzhou river snail sauce	[41]
		DBS 45/034-2021 Food safety local standard-Liuzhou Luosifen	[42]
		T/LZLSF 009.1-2022 Ingredient packets of Liuzhou Luosifen-Part 1: Packet of semi-dry rice noodles/semi-dry vermicelli	[43]
		T/LZLSF 009.2-2022 Ingredient packets of Liuzhou Luosifen-Part 2: Packet of river snail meat	[44]
		T/LZLSF 009.3-2022 Ingredient packets of Liuzhou Luosifen-Part 3: Packet of liquid compound seasoning	[45]
		T/LZLSF 009.4-2022 Ingredient packets of Liuzhou Luosifen-Part 4: Packet of pickled bamboo shoots	[46]
		DB4502/T 0008-2022 Production specification for physical store of Liuzhou Luosifen	[47]
		T/LZLSF 002-2019 Specifications for disinfection and sterilization of Liuzhou Luosifen	[48]
		T/LZLSF 004-2022 Technical specification for quality control in prepackaged Liuzhou Luosifen production	[49]
		DB4502/T 0015-2022 Technical requirements for traceability of pre-packaged Liuzhou Luosifen products	[50]
Cultivation of raw materials	Base construction and management	T/GXAS 287-2022 Demonstration base construction specifications for bamboo shoots planting of rawmaterials of Liuzhou Luosifen	[51]
		DB4502/T 0040-2022 Raw materials of Liuzhou Luosifen-specification for construction of bamboo shoots planting base	[52]
		DB4502/T 0041-2022 Raw materials of Liuzhou Luosifen-specification for evaluation of bamboo shoots planting base	[53]
		DB4502/T 0033-2022 Construction specification for pre-packaged fresh Liuzhou Luosifen factory	[54]
		DB4502/T 0034-2022 Construction and renovation specification of manufacturing plant of pre-packaged Liuzhou Luosifen factory	[55]
		DB4502/T 0036-2022 Specification of river snail breeding base construction	[56]
		DB4502/T 0027-2022 Specification for disinfection and sterilization of Liuzhou Luosifen	[57]
	Origin environment	DB4502/T 0027-2022 Specification for disinfection and sterilization of Liuzhou Luosifen	[57]
		T/GXAS 383-2022 Seedling quality grading of bamboo shoots of raw materials of Liuzhou Luosifen	[58]
	Breeding operations	DB4502/T 0037-2022 Pear-shaped ringed edge snail	[59]
T/GXAS 286-2022 Technology code of practice for container seedling of bamboo shoots of raw materials of Liuzhou Luosifen		[60]	
DB4502/T 0002-2022 Raw materials of Liuzhou Luosifen-technical code of practice for production of bamboo shoots		[61]	
DB4502/T 0003-2022 Technical specification for Liuzhou river snail		[62]	
DB4502/T 0050-2022 Technical specification for selective breeding of <i>Bellamya</i> sp strains		[63]	
Production and operation	Raw material procurement	T/LZLSF 008.1-2022 Quality of raw materials for prepackaged Liuzhou Luosifen-Part 1: Rice for Luosifen	[64]
		T/LZLSF 008.2-2022 Quality of raw materials for prepackaged Liuzhou Luosifen-Part 2: River snail for Luosifen's soup stock	[65]
		T/LZLSF 0011-2022 Pre-packaged Liuzhou Luosifen raw material procurement planning and management guide	[66]
		T/LZLSF 001-2019 Specification for production of Liuzhou Luosifen soup (matching) material package	[67]
	Production and processing	DB4502/T 044-2022 Technical specification for intelligent manufacturing of Liuzhou Luosifen	[68]
		DB4502/T 0029-2022 Technical regulation of raw materials processing of pre-packaged Liuzhou Luosifen-Part 1: Dried rice noodles	[69]
		DB4502/T 0030-2022 Technical regulation of raw materials processing of pre-packaged Liuzhou Luosifen-Part 2: Pickled bamboo shoots	[70]
		DB4502/T 0031-2022 Technical regulation of raw materials processing of pre-packaged Liuzhou Luosifen-Part 3: Frozen snail meat	[71]
		DB4502/T 0032-2022 Technical regulation of raw materials processing of pre-packaged Liuzhou Luosifen-Part 5: Semi-dried rice noodles/semi-dried rice vermicelli	[72]

(to be continued)

Table 3. (continued)

Corresponding to the standard system	Project	Standard name	Reference
Marketing and circulation	Inspection and testing	DB4502/T 0001-2022 Technical code of practice for raw materials of pre-packed Liuzhou Luosifen processing-Part 4: Sour beans	[73]
		DB4502/T 0004-2022 The specification of processing craft of Liuzhou Luosifen chili oil kit	[74]
		DB4502/T 0007-2022 Production specification for physical store of Liuzhou Luosifen	[75]
		Technical specification for raw material packaging of Liuzhou Luosifen physical store (Unpublished standard)	[76]
		DB4502/T 0013-2022 Technical specification for processing and storage of snail flesh for Liuzhou Luosifen	[77]
		DB4502/T 0026-2022 Production operation specification for prepackaged liquid compound seasoning with snail meat as the main raw material used in Liuzhou Luosifen	[78]
		DB4502/T 0038-2022 Technical specification for river snail formula feed processing	[79]
		DB4502/T 0051-2022 Detection method of broken rate, cooked broken rate, cooking loss rate and broken powder rate of Liuzhou Luosifen dried rice noodles	[80]
		DB4502/T 0017-2022 The evaluation methods of Liuzhou Luosifen sensory flavor	[81]
		DB4502/T 0018-2022 Design and application specification of Liuzhou Luosifen flavor wheel	[82]
	Business management	T/LZBX 018-2021 Requirements for the equipment and management of measuring instruments in pre-packaged Luosifen production enterprises	[83]
		DB4502/T 0012-2022 Management specification for cold chain logistics (warehousing and distribution) technology of Liuzhou Luosifen raw materials	[84]
	Warehousing and logistics	DB4502/T 0014-2022 Technical specification for low temperature storage of fresh snails	[85]
		DB4502/T 0028-2022 Technical specification for packaging of prepackaged Liuzhou Luosifen	[86]
	Marketing and management (online and offline)	DB4502/T 0043-2022 Technical specification for management of prepackaged Luosifen wholesale enterprise	[87]
		T/LZLSF 0012-2022 Technical specification for Liuzhou Luosifen e-commerce platform	[88]
		DB4502/T 0005-2022 Specification for marketing and operation management of Liuzhou Luosifen	[89]
		DB4502/T 0006-2022 Specification for chain shop general management of Liuzhou Luosifen	[90]
		DB4502/T 0009-2022 Star rating technical specification for physical store of Liuzhou Luosifen	[91]
		DB4502/T 0042-2022 Specification for managing risk grading evaluation of prepackaged Luosifen	[92]
		Quality management standards for pre-packaged Liuzhou Luosifen production enterprises (Unpublished standard)	[93]
		DB4502/T 0010-2022 Management specification for prepackaged Liuzhou Luosifen stores and sales exhibition service	[94]
		DB4502/T 0011-2022 Requirement and evaluation specification for Liuzhou Luosifen sales service	[95]
DB4502/T 0016-2022 Code of conduct for Liuzhou Luosifen livestreaming marketing		[96]	
Application of scenario	Industrial parks	DB4502/T 0049-2022 Specification for construction and management of Liuzhou Luosifen cultural industry demonstration park and base	[97]
		DB4502/T 0045-2022 Specifications of facilities and services for industrial park of characteristic rice noodle	[98]
		DB4502/T 0046-2022 General requirements for the information management system of industrial park of characteristic rice noodle	[99]
		DB4502/T 0047-2022 Specifications of emergency management capacity building for industrial park of characteristic rice noodle	[100]
		DB4502/T 0048-2022 Specifications of safety production for industrial park of characteristic rice noodle	[101]
	DB4502/T 0035-2022 Regulations for the construction of food (Liuzhou Luosifen) industry park	[102]	
	Characteristic town	T/LZLSF 0013-2022 Luosifen small characteristic town-specifications for operation management	[103]
		T/LZLSF 0015-2022 Luosifen small characteristic town-specification of town living room construction	[104]
	Cultural tourism	T/LZLSF 0014-2022 Luosifen small characteristic town-specification of tourism service	[105]
		DB4502/T 0039-2022 Service specification of Liuzhou Luosifen culture tourism	[106]
Brand creation, application, protection and management	Brand creation, use and protection	T/LZLSF 003-2022 Geographical indication trademark-Liuzhou Luosifen	[107]
		T/LZLSF 0018-2022 Geographical indication Liuzhou Luosifen raw materials Part 1: Liuzhou dry rice flour	[108]
		T/LZLSF 0019-2022 Geographical indication Liuzhou Luosifen raw materials Part 2: Liuzhou sour bamboo shoots	[109]
		DB4502/T 0024-2022 Liuzhou Luosifen brand evaluation-Part 1: Regional public brand	[110]
		DB4502/T 0025-2022 Liuzhou Luosifen brand evaluation-Part2: Enterprise brand	[111]
	DB4502/T 0019-2022 Liuzhou Luosifen regional public brand cultivation guide	[112]	
	DB4502/T 0021-2022 The protection specification for the geographical indication trademark of Liuzhou Luosifen	[113]	
	DB4502/T 0022-2022 Requirement for the brand construction of Liuzhou Luosifen	[114]	
	Brand management	DB4502/T 0020-2022 The management specification for the geographical indication trademark of Liuzhou Luosifen	[115]
		DB4502/T 0023-2022 Specification for brand management of Liuzhou Luosifen	[116]

Luosifen industry standards. Food safety and food quality control management and traceability serve as the basic support for the standard system of the whole industry chain of Liuzhou Luosifen.

Raw material breeding

The rapid development of the Liuzhou Luosifen industry cannot be separated from the efficient raw material cultivation management and breeding technology, as well as the scientific construction and management of the base, effective pest control, agricultural and veterinary fertilizers, which are important bases to ensure the yield and quality. However, the standards involved in this aspect are not perfect, and there are no special local standards in pest control and agricultural and veterinary fertilizers. It is far from meeting the current needs of industrial standardization only with the limited space in other standards. At present, the varieties of Liuzhou Luosifen are mixed and the quality is uneven. It is urgent to formulate relevant standards for the identification and evaluation of raw materials in the whole industry chain of Liuzhou Luosifen.

Production and operation

Most of the raw materials are mixed and prepared after simple processing, and the final product has complex ingredients, diverse auxiliary materials and difficult quality control. At present, standards with certain coverage have been formulated in the production and processing of Liuzhou Luosifen, but targeted inspection standards have not been formulated, so unified inspection and testing standards of the industry should be formulated according to Liuzhou Luosifen products. In addition to the professionalism, high efficiency and operability of the traditional inspection and identification methods, they also need to pay more attention to the complexity of the testing components and standardize the overall technology of the product.

Marketing and circulation

For the marketing and circulation management of Liuzhou Luosifen, Liuzhou has formulated online and offline marketing standards based on the local industrial characteristics and economic characteristics. It not only pays attention to the standardization of Liuzhou Luosifen logistics and transportation, but also pays attention to the adaptation of Liuzhou Luosifen marketing mode and local standard systems. Centering on Liuzhou Luosifen products, the influence of the industrial system is expanded through online and offline media promotion, which fully reflects the supporting role of standards for the high-quality development of the Liuzhou Luosifen industry.

Scene application

Scene application of Liuzhou Luosifen mainly includes three aspects: industrial park, characteristic town and cultural tourism. The construction of the industrial park focuses on demonstration and promotion, strengthens the publicity and cross training of the whole industrial chain, promotes the development of leading enterprises, but the implementation time is short according to the industrial development in the future. In the characteristic town and cultural tourism, Liuzhou built Luosifen town in 2021, and strives to build it into a 4A level scenic spot.

Brand creation, application, protection and management

With the acceleration of the standardization process of the whole industry chain of Liuzhou Luosifen, Liuzhou city quickly

formulated relevant standards for geographical indications and brands. The purpose is to promote cooperation between Liuzhou City, leading snail rice noodle enterprises, and the Liuzhou Luosifen association to jointly create a regional characteristic brand.

Discussion

Since 2016, Liuzhou, Guangxi, has established dozens of Liuzhou Luosifen standards, among which the new requirements also need to timely follow up and supplement the appropriate production technical procedures and inspection methods. Each enterprise generally establishes separate production technical procedures and supporting inspection methods for products. The current local standards of Liuzhou Luosifen mainly focus on the production and processing links. In view of the supporting inspection methods of Liuzhou Luosifen products, it is suggested to carry out special investigation for Liuzhou Luosifen enterprises on a large scale, and collect and analyze the data of supporting inspection methods of each enterprise. According to the characteristics of the food matrix of Liuzhou Luosifen products, the supporting standards that can meet the special testing needs without violating the national food safety standards are formulated. At the same time, the opinions of standard users such as Liuzhou Luosifen enterprises and testing institutions are collected, and actively improve the standards of risk monitoring and evaluation and production supervision of products. In addition, we should continue to learn from the advanced production management experience of characteristic industries in other parts of the world, formulate, revise and improve the standard system in line with the local economic development of Liuzhou in time, and promote the standardized development of the Liuzhou Luosifen industry in a comprehensive and efficient way.

Claims

Consumption intention of Liuzhou Luosifen

Based on the green and healthy production concept of controlling the source of Liuzhou Luosifen, consumers have a high recognition and loyalty to the authentic Liuzhou Luosifen, not only because of its taste, but also because this traditional delicacy represents an emotional bond and cultural heritage. In Liuzhou, Luosifen is an essential part of people's daily lives, and only authentic Liuzhou Luosifen can make them feel the taste and emotion of their hometown.

To start with, Liuzhou Luosifen is regarded as an important festive food in Liuzhou. For instance, during certain traditional festivals in the region, such as the Dragon Boat Festival and the Mid-Autumn Festival, people prepare Liuzhou Luosifen specially to commemorate the occasion. Additionally, there are even moon cakes and rice dumplings with Luosifen flavor available for purchase. Secondly, the technique and formula for making Luosifen in the local area have been passed down through several generations. There are many well-known traditional Luosifen shops in Liuzhou. Their methods of making the dish have been handed down from their ancestors and are closely guarded secrets. These historic shops have become a unique and renowned landmarks in the area. Thanks to the efforts of various parties, the 'Luosifen Handmade Process' was successfully listed in the National Intangible Cultural Heritage list at the end of 2020, which has better protected and inherited this important intangible cultural heritage, and also

improved the popularity and reputation of Luosifen, promoting the dissemination and development of Luosifen culture.

Economic benefits of crop farming and aquaculture

Liuzhou Luosifen has brought significant economic benefits to both crop farming and aquaculture industries in the region. Firstly, the production of rice noodles, which are one of the main ingredients in Luosifen, has boosted the demand for high-quality rice from local farmers. This has helped to increase rice production and improve the livelihoods of rice farmers in the area. Moreover, the production of Luosifen requires a variety of ingredients, including fresh vegetables, and snails. This has led to an increase in demand for these products, which in turn has stimulated the growth of vegetable farming, and aquaculture industries in the region.

According to the official website, in 2021, the scale of Liuzhou's raw material base for Luosifen was about 552,000 acres, creating more than 300,000 job opportunities and lifting 55,000 impoverished households and 28,000 people out of poverty. Among them, the area of snail breeding is 60,000 acres (with 10,000 acres as the main breeding area and 50,000 acres as the auxiliary), with a production of 18,000 tons; the area of bamboo shoots planting is 75,000 acres, with a production of 64,000 tons; the area of processing-type beans planting is 28,500 acres, with a production of about 51,300 tons; the number of black fungus plantation is 8 million sticks, with a production of about 10,000 tons; and the area of leafy vegetables is 158,000 acres, with a production of 277,000 tons^[29]. In order to provide high-quality raw materials for the Luosifen industry and strengthen the supervision of agricultural product quality and safety, 12 demonstration bases for Liuzhou's Luosifen raw materials (bamboo shoots, rice, beans, black fungus, snails, etc.) have been recognized, with a total area of 16,500 acres^[29].

Historical development of Liuzhou Luosifen

The earliest existing individual business license for Luosifen dates back to 1988 from a roadside stall. In 2008, the 'Luosifen Handmade Production Skill' in Liuzhou was included in the list of regional intangible cultural heritage. At the same time, restaurants in Liuzhou began to introduce Luosifen, and the business model became diversified, with Luosifen evolving from a street snack to a formal dish. In 2011, the Liuzhou Government encouraged local Luosifen operators to open stores in big cities such as Beijing, Shanghai, and Shenzhen, in order to promote the city's image. In 2012, a documentary called 'China on the Tongue' introduced the production of one of Luosifen's ingredients, sour bamboo shoots, in its first season. In September of the same year, Liuzhou launched the 'Ten Thousand People Tasting Luosifen' event, and built a 'world's largest pot' with a diameter of 10 m and a height of 3 m for tens of thousands of citizens and tourists to taste the traditional Liuzhou dish for free. In 2014, Quanhui Food Co., Ltd. obtained the first pre-packaged Luosifen production license in Liuzhou, marking the beginning of industrialization of Luosifen production. Dozens of pre-packaged Luosifen production enterprises quickly emerged and developed, coinciding with the popularization of domestic e-commerce. In subsequent years, Liuzhou began to pursue the idea of developing the Luosifen industry in a standardized, branded and scaled way, and the Luosifen industry began to move towards industrialization, producing fast food-style, standardized, noodle-like, and

characteristic products for sale throughout the country. In 2015, the Liuzhou government held the Luosifen Industry Development Conference and proposed the idea of 'industrialization, standardization, branding, and scaling' for the development of the Luosifen industry. Since then, the development of Luosifen has been mainly through the industrialized pathway, using mechanical production methods to produce pre-packaged Luosifen. In the same year, the Liuzhou Luosifen Association was established to work with relevant departments to develop industry standards and regulations for the production and sale of Luosifen. In 2016, the first local standard for Liuzhou Luosifen was officially released. Subsequently, more supporting local standards were also introduced. In 2018, 'Liuzhou Luosifen' was awarded the Chinese national geographical indication trademark. In 2020, the Liuzhou Vocational and Technical College, guided and supported by the Liuzhou Municipal Bureau of Commerce and industry enterprises, established the Liuzhou Luosifen Industry College. The rise of pre-made dishes in 2020 also brought about many non-food enterprises to launch joint Luosifen products. In 2021, Luosifen-flavored mooncakes were introduced during the Mid-Autumn Festival, and in 2022, significant progress was made in the development of key Luosifen standards, with the full production chain standards system achieving comprehensive coverage.

Support from the government and society

The government has been devoted to exploring the potential and driving the development of the Liuzhou Luosifen industry with the joint efforts of various sectors of society. From the government's perspective, firstly, it has accelerated the pace of building a financial support platform for the Luosifen industry chain. Secondly, it has supported the expansion of the production scale of Luosifen raw materials, including supporting the development of Luosifen raw materials industry and supporting the construction of Luosifen raw materials industry demonstration bases. Thirdly, it has supported the construction of a standardized system for the entire Liuzhou Luosifen industry chain. As of June 2022, a total of 60.5527 million yuan has been arranged from the local government financial funds to mainly support the construction of Luosifen raw material bases and the development of the Liuzhou Luosifen industry. From the perspective of society, the establishment of the Liuzhou Luosifen Association and the Liuzhou Luosifen Industry Institute has further promoted the healthy development of the industry in terms of management and production. In addition, collaborative products with Luosifen, such as those launched by car manufacturers like Wuling, have helped to elevate the popularity of Luosifen.

Economic driving effect

According to a report on China's Luosifen industry trends and future investment research (2023-2030), the upstream of the Liuzhou Luosifen industry consists of raw materials, mainly including snails, sour bamboo shoots, sour beans, rice, and wood ear mushrooms. The midstream consists of Luosifen producers, and the downstream consists of Luosifen sales channels, including supermarkets, restaurants, e-commerce, and O2O platforms. According to the data provided by the Commerce Bureau of Liuzhou City, Guangxi, in 2021, the total sales revenue of the entire Luosifen industry chain in Liuzhou was 50.16 billion yuan, of which sales revenue from packaged Liuzhou Luosifen reached 15.197 billion yuan^[29]. There are currently more than 23,000 Luosifen-related companies across

the country. The local government has announced that in 2022, the sales revenue of pre-packaged Liuzhou Luosifen reached RMB 18.2 billion yuan, a year-on-year increase of 19.6%^[29]. The annual delivery volume exceeded RMB 100 million yuan, and exports reached 83 million yuan^[29]. In 2022, Liuzhou Luosifen were sold to 28 countries and regions worldwide, and there is even a physical store for Luosifen named 'Female Cousin's Luosifen' in New York (USA).

As a traditional specialty food of Liuzhou, Luosifen not only directly drive the economic development of Luosifen production and sales, but also play an important role in promoting the development of other related industries. The development of the Luosifen industry has driven the prosperity of the tourism industry in Liuzhou. The delicious taste and unique characteristics of Luosifen attract more and more tourists to come to Liuzhou to taste and learn about the history and culture of Luosifen. Liuzhou is also actively promoting the cultural tourism of Luosifen, such as setting up Luosifen museums and Luosifen-themed blocks in scenic spots and city centers, organizing Luosifen cultural festivals and related activities, etc. These measures have attracted a large number of tourists to visit and experience the charm of Liuzhou. During the May Day holiday, Liuzhou received 3.9014 million tourists, up 103.6% year on year, according to data provided by Liuzhou Culture, Radio, Film and Tourism Bureau. Tourism consumption reached 3.593 billion yuan, up 111.1% year on year. Liuzhou Luosifen attracts tourists from all over the country to 'punch in'^[30]. The transportation industry has been strengthened and developed as well. For example, the road and railway transportation between Liuzhou and other cities have been improved and upgraded to meet the travel needs of more tourists and business people.

The development of the Liuzhou Luosifen industry has had a positive impact on the local human resources and machinery manufacturing industry. Firstly, the production of Luosifen requires a large amount of labor, from the procurement of raw materials to processing and sales, many workers need to be involved. In 2019, based on the resource advantages of the Liuzhou Luosifen industry parks, the Liuzhou Luosifen raw material core demonstration area was created, and a new model of industry poverty alleviation was established with the participation of leading enterprises, village committees, professional cooperatives, bases, and farmers. Therefore, the development of the Luosifen industry has not only created a large number of job opportunities, but also provided opportunities for local labor training, improving the skills and level of local labor force. Secondly, the processing of Luosifen requires a large amount of machinery, such as grinding machines, steamers, and noodle cutters. This requires the corresponding equipment and tools provided by the local machinery manufacturing industry. Therefore, the development of the Luosifen industry has played a certain role in driving the machinery manufacturing industry, bringing more business opportunities and chances for the local machinery manufacturing industry.

Conclusions

Over the past years, Liuzhou Luosifen have been put under the spotlight by policymakers and researchers. For regional economic development, policymakers have promoted Liuzhou Luosifen as a local industrial lever for change towards more

inclusive, resilient and sustainable economic systems. This study provides a comprehensive look at the impact of Liuzhou Luosifen flavor and standards on the industry and regional economy. Although Liuzhou Luosifen is actively promoted around the world, it is still a niche market, and the continuous growth of the industry is still a big challenge.

Overall, the impact of Liuzhou Luosifen on flavor, economic and industrial factors highly depend on the type of supply chain under assessment. Firstly, Liuzhou Luosifen has increased local residents' access to fresh, green food. Secondly, consumers are willing to pay a premium for local food rather than non-local food because of their buying habits. Thirdly, Liuzhou's local farming and aquaculture industries supply most of the raw materials for Luosifen. Fourthly, according to data released by the local government, local farmers have benefited greatly from this economic model. Fifthly, Liuzhou Luosifen, a traditional snack, has fully promoted its affiliated basic industries, such as raw material cold chain transportation, road transportation, tourism (Luosifen cultural town) and cultural publicity (brand culture), plastic packaging industry, etc. Sixthly, the complete standard system of Liuzhou Luosifen has standardized the products and guaranteed the quality of the products. According to our research, we recommend that policy makers should further integrate international food standard requirements into local standards (especially in Europe and the USA), which would bring Liuzhou Luosifen product quality into line with national food import standards. Seventhly, the release of relevant statistical data is too general. If local authorities can release detailed data, it will be more convenient to guide enterprises to produce. Eighthly, if Liuzhou are to contribute to the transition towards more sustainable economic systems, the question of their up-scaling needs to be addressed. More distribution channels need to be tapped. The integration of local food products into local institutions' food programs, such as schools and hospitals, represents valuable opportunities that should be promoted.

Author contributions

The authors confirm contribution to the paper as follows: study conception and design: Zhao Z, Chen J, Zhan Q; data collection: Chen J; analysis and interpretation of results: Zhao Z, Jiang Y; draft manuscript preparation: Chen J, Zhao Z, Liu T. All authors reviewed the results and approved the final version of the manuscript.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Conflict of interest

The authors declare that they have no conflict of interest.

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