Journal of Global Change Data & Discovery. 2026, 10(3): 282-296
www.geodoi.ac.cn

GIES Case Study on Wangqing Black Fungus Facility Agriculture Mountain Valleys in Jiguan Township

YE Yinghui[1*] ZHAO Yong[2] LI Enhua[2] GAO Mingxu[2] WANG Jisheng[3] SONG Yubin[5] GAO Bin[4] WANG Yichun[3] XIA Wenqiang[6] WEI Yuncheng[7] HAN Yan[8] YAO Fangjie[9] WANG Bin[10] LIN Yan[11] LENG Liang[1] LU Peng[1] CHEN Shengbo[1] WU Di[12]

1. College of Geo-Exploration Science and Technology, Jilin University, Changchun 130062, China; 2. People's Government of Wangqing County, Wangqing 133200, China; 3. Wangqing County Market Supervision and Administration Bureau, Wangqing 133200, China; 4. Wangqing County Bureau of Agriculture and Rural Affairs, Wangqing 133200, China; 5. People's Government of Jiguan Township, Wangqing County, Wangqing 133200, China; 6. Yanxing Edible Fungi Professional Cooperative of Wangqing County, Wangqing 133200, China; 7. Jixing Edible Fungi Planting Professional Cooperative of Wangqing County, Wangqing 133200, China; 8. Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China; 9. Jilin Agricultural University, Changchun 130021, China; 10. Wangqing Bei'er Technology Co., Ltd., Wangqing 133200, China; 11. Jilin Jiguan Edible Fungi Technology Development Co., Ltd., Wangqing 133200, China; 12. Jilin Institute of GF Remote Sensing Application Co., Ltd., Changchun 130118, China

Abstract: Black fungus is a well-known edible and medicinal fungus in China and ranks among the world's four major edible fungi. The GIES case area on Wangqing black fungus is located in the mountain valleys of Jiguan Township, central Wangqing County, Yanbian Korean Autonomous Prefecture, Jilin Province, within the main mountainous area of the Changbai Mt. It is situated 35 km from the county seat, with a total area of 818.24 km^2, a total population of 7,865. The terrain of the case area slopes from northeast to southwest, featuring rugged mountainous land in the northeast and staggered hills and valleys in the southwest. The average elevation ranges from 600 to 800 m. With a large diurnal temperature variation and abundant negative oxygen ions, the regional environment is highly conducive to the growth of black fungus. The case area boasts a superior ecological environment with no severe pollution, a favorable climate, and sound soil conditions. Its unique physical and geographical characteristics foster the cultivation of high-quality black fungus in Jiguan Township. The supporting dataset for this study includes ecological environment data (geographical location, altitude, meteorology, hydrology, soil, etc.), black fungus product characteristic data, socioeconomic and management data, as well as historical, cultural, and developmental data of the case area. The data formats include .shp, .tif, .xlsx, .docx, and .jpg, with a total volume of 80.2 MB. This dataset provides essential data support for research on low-mountain forest ecological protection and the sustainable development of characteristic agricultural products.

Received: 06-01-2026; **Accepted:** 11-05-2026; **Published:** 25-06-2026
Foundation: Jilin Provincial Administration for Market Regulation (2025)
***Corresponding Author:** Ye, Y. H., College of Geo-Exploration Science and Technology, Jilin University, yyh13@jlu.edu.cn
Data Citation: [1] Ye, Y. H., Zhao, Y., Li, E. H., *et al*. GIES case study on Wangqing black fungus facility agriculture mountain valleys in Jiguan Township [J]. *Journal of Global Change Data & Discovery*, 2026, 10(3): 282–296. https://doi.org/10.3974/geodp.2026.03.05.
[2] Ye, Y. H., Zhao, Y., Li, E. H., *et al*. GIES case dataset on Wangqing black fungus facility agriculture mountain valleys in Jiguan Township [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2026. https://doi.org/10.3974/geodb.2026.02.07.V1.

Keywords: Changbai Mountain; Wangqing County; Jiguan Township; black fungus; facility agriculture; GIES; Case 32

DOI: https://doi.org/10.3974/geodp.2026.03.05

Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2026.02.07.V1.

1 Introduction

1.1 Research Background

As a traditionally valued edible and medicinal fungus in China, black fungus plays a crucial role in ensuring food security, enhancing agricultural efficiency, and increasing farmers' incomes[1–4]. Benefiting from its unique mountainous forest ecological environment, Jiguan Township in Wangqing County has developed the black fungus industry for more than 40 years, gradually establishing an industrial model characterized by large-scale cultivation and standardized management. This industry has become a pillar supporting regional rural revitalization (Figure 1)[5,6].

Figure 1 Black fungus in Jiguan Township, Wangqing County

This study systematically collects ecological environment data, product quality data, and socio-economic data from black fungus cultivation areas in Jiguan Township to construct a case dataset aimed at mountainous forest habitat conservation and sustainable development. The research not only provides a scientific basis for optimizing high-quality, high-yield cultivation techniques of black fungus and ecological environmental protection but also offers a reference model for the sustainable development of similar geographically indicated agricultural products. Therefore, it holds significant theoretical and practical value for promoting the coordinated development of mountain ecological economies and supporting the implementation of rural revitalization strategies.

1.2 Case Area

The case area is Jiguan Township, located within Wangqing County, Yanbian Korean Autonomous Prefecture, Jilin Province. It lies in the central part of the county, with geographical coordinates ranging from 129°30′E to 130°10′E and 40°00′N to 40°01′N. The township is bordered by Luozigou Town to the east, Wangqing Town and Dongguang Town to the south, Daxinggou Town to the west, and Tianqiaoling Town to the north. The administrative area covers 818.24 km^2, with a total population of 7,865 (Figure 2).

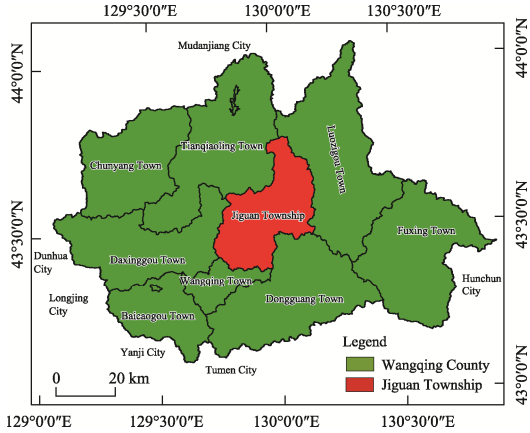

Figure 2 Geo-location map of Jiguan Township

The township is situated in the Changbai Mt. region, within the Jiguan River Basin, a tributary of the Gaya River. The terrain rises toward the northeast and descends toward the southwest. The northeastern area features mountainous and rugged landscapes, while the southwestern area is relatively gentle, characterized by interlaced river valleys. The average elevation is approximately 0.8 km. The main mountains in the area include Qichejian Ridge, Tudingzi, and Dapingtou, with Qichejian Ridge being the highest peak at 1.1 km. The lowest point is located in Dabeigou Village in the western part of the township, at an elevation of 280 m (Figure 3). Black fungus grows best in gently sloping mid- and low-mountain areas at elevations between 250 and 850 m, with slopes less than 15° being optimal. The climate is classified as temperate continental monsoon, characterized by strong spring winds, short and rainy summers, cool and clear autumns, and long, cold winters. According to statistics from the Wangqing County Meteorological Bureau[1], the annual average temperature is 4.8 ℃, with an average January temperature of –16.8 ℃ and an extreme minimum of –31 ℃. In July, the average temperature is 23.6 °C, with an extreme maximum of 35 ℃. The region is rich in water resources with excellent water quality; all river water quality indicators meet national standards. Additionally, the area has a high forest coverage rate (Figure 4). Black fungus cultivation primarily relies on open spaces beneath oak and birch forests, reforested former cropland, and gently sloping abandoned non-arable land. These typical mountainous agricultural and climatic characteristics provide favorable natural conditions for black fungus growth.

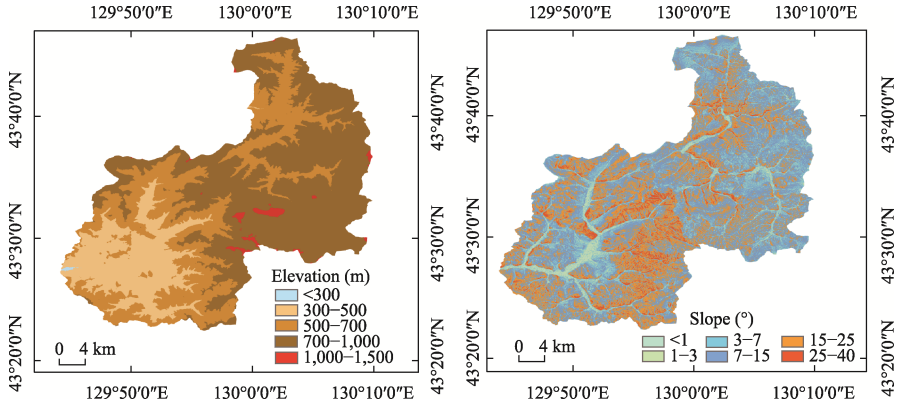

Figure 3 Classification maps of elevation and slope in Jiguan Township

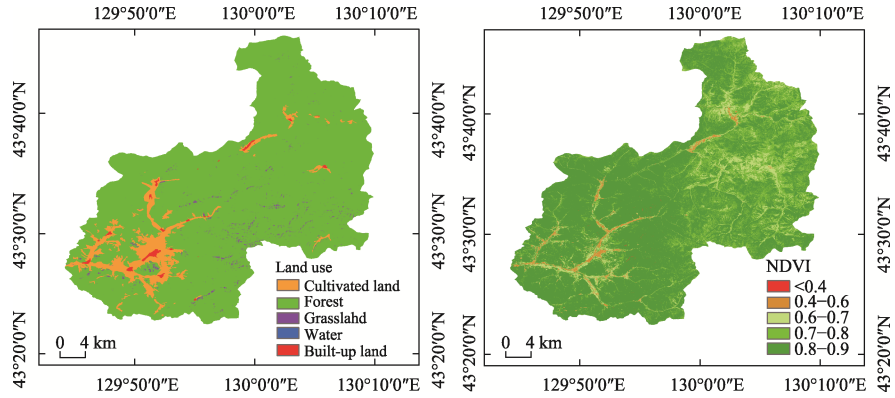

Figure 4 Land use and NDVI distribution maps of Jiguan Township

[1] Data source: Wangqing County Meteorological Bureau.

1.3 Research Content and Data Composition

This study focuses on 3 main aspects. First, it systematically investigates the ecological and geographical characteristics of black fungus cultivation areas in Jiguan Township, including key factors such as meteorology, soil, and hydrology. Second, it analyzes the quality characteristics of black fungus products and related production factors, particularly cultivation substrate bags. Third, it examines the socioeconomic effects and management models of the black fungus industry in the region. The supporting dataset comprises 5 data folders: the case area boundary data, natural geographic data, variety characteristic data, operation and management data, product culture and historical tradition data, and photographs related to the case area. Together, these datasets comprehensively cover the natural, economic, and social dimensions of black fungus industry development.

2 Metadata of the Dataset

The metadata information of the GIES case dataset on Wangqing black fungus facility agriculture mountain valleys in Jiguan Township[7] including the title, author, geographical region, data size, data file, etc., is summarized in Table 1.

Table 1 Metadata summary of the GIES case dataset on Wangqing black fungus facility agriculture mountain valleys in Jiguan Township

Items	Description
Dataset full name	GIES case dataset on Wangqing black fungus facility agriculture mountain valleys in Jiguan Township
Dataset short name	WangqingBlackFungusCase32
Authors	Ye, Y. H., School of Geo-Exploration Science and Technology, Jilin University, yyh13@jlu.edu.cn Zhao, Y., People's Government of Wangqing County, wqsjjzhk@163.com Li, E. H., People's Government of Wangqing County, wqsjjzhk @163.com Gao, M. X., People's Government of Wangqing County, wqsjjzhk@163.com Wang, J. S., Wangqing County Market Supervision and Administration Bureau, wqsjjzhk@163.com Song, Y. B., People's Government of Jiguan Township, Wangqing County, wqsjjzhk@163.com Gao, B., Wangqing County Bureau of Agriculture and Rural Affairs, wqsjjzhk@163.com Wang, Y. C., Wangqing County Market Supervision and Administration Bureau, wqsjjzhk@163.com Wang, B., Wangqing Bei'er Technology Co., Ltd., wqsjjzhk@163.com Lin, Y., Jilin Jiguan Edible Fungi Technology Development Co., Ltd., wqsjjzhk @163.com Xia, W. Q., Yanxing Edible Fungi Professional Cooperative of Wangqing County, wqsjjzhk@163.com Wei, Y. C., Jixing Edible Fungi Planting Professional Cooperative of Wangqing County, wqsjjzhk@163.com Han, Y., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, hanyan78@163.com Yao, F. J., Jilin Agricultural University, yaofj@jlau.edu.cn Lengliang, School of Geo-Exploration Science and Technology, Jilin University, lengliang@jlu.edu.cn Lu, P., School of Geo-Exploration Science and Technology, Jilin University, lupeng@jlu.edu.cn Chen, S. B., School of Geo-Exploration Science and Technology, Jilin University, chensb@jlu.edu.cn Wu, D., Jilin Institute of GF Remote Sensing Application Co., Ltd., 1065142435@qq.com
Geographical region	Jiguan Township, Wangqing County, Yanbian Korean Autonomous Prefecture, Jilin Province
Year	2000–2025
Data format	.shp, .tif, .xlsx, .docx, .jpg
Data size	80.2 MB
Data files	Case area boundary, natural geographic data, black fungus product characteristic data, etc.
Foundation	Jilin Provincial Administration for Market Regulation (2025)

(*To be continued on the next page*)

(*Continued*)

Items	Description
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No.11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	(1) *Data* are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use *Data* subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute *Data* subject to written permission from the GCdataPR Editorial Office and the issuance of a *Data* redistribution license; and (4) If *Data* are used to compile new datasets, the "ten percent principle" should be followed such that *Data* records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[8]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC

3 Geographical and Environmental Data

3.1 Data Collection Methods

The ecological environment data for the case area were collected using an integrated approach that combined satellite remote sensing with laboratory testing. First, satellite remote sensing data were integrated with long-term meteorological statistics to construct time series of climatic factors. Second, field sampling was conducted, and laboratory analyses of soil, product and water samples were performed to ensure data accuracy and comprehensiveness.

3.2 Climatic Conditions

According to statistics from the Wangqing County Meteorological Bureau, climatic factors in the case area from 2000 to 2023—including average precipitation, average temperature, sunshine percentage, sunshine duration, and frost-free period—exhibited stable interannual variation characteristics (Figure 5–10), without extreme or abnormal fluctuations. These climatic conditions align with the growth requirements of black fungus, whose mycelia prefer a relatively dry environment with temperatures between 22 and 28 ℃. The fruiting stage requires temperatures of 20 to 25 ℃, high humidity, cool and shaded conditions, sufficient diffused light, alternating dry and wet periods, and good ventilation.

3.3 Soil Conditions

The authors collected soil samples from 4 primary black fungus cultivation sites within the case area (Figure 11), where field sampling and soil profile observations were also conducted (Figure 12). The predominant soil types in the case area are black soil and chernozem-like, calcium-rich black soil.

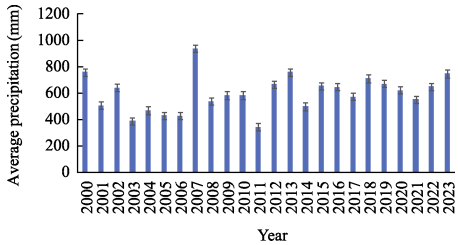

Figure 5 Statistics of average precipitation in Wangqing County (2000–2023)

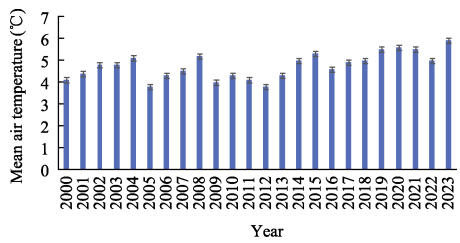

Figure 6 Statistical chart of average temperature in Wangqing County (2000–2023)

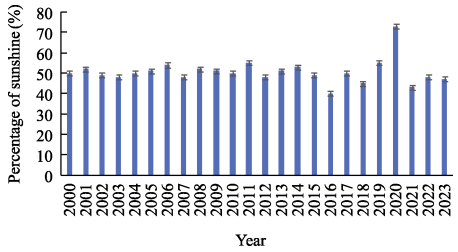

Figure 7 Statistical chart of sunshine percentage in Wangqing County (2000–2023)

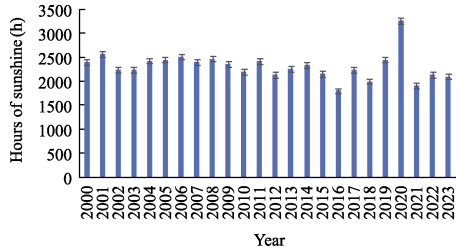

Figure 8 Statistical chart of sunshine hours in Wangqing County (2000–2023)

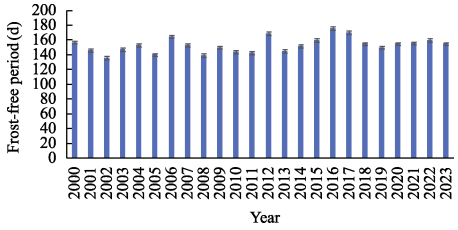

Figure 9 Statistics of frost-free days in Wangqing County (2000–2023)

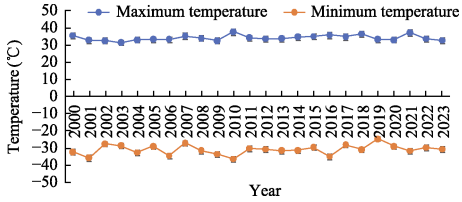

Figure 10 Statistical chart of maximum and minimum temperature in Wangqing County (2000–2023)

Figure 11 Distribution map of sampling sites

Figure 12 Case group members investigation, field sampling

According to the Soil environmental quality risk control standard for soil contamination of agricultural land (Trial) (GB 15618—2018)[9], heavy metals and nutrient elements in the soil samples were analyzed. The test results, provided by the Testing Department of the Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences (Table 2), showed that the heavy metal concentrations in all 4 soil samples were well below the national standard limits, indicating excellent soil environmental quality. Additionally, the soils were rich in nutrient elements such as calcium (Ca), potassium (K), magnesium (Mg), phosphorus (P), and iron (Fe), providing favorable nutrient conditions for black fungus growth.

3.4 Black Fungus Cultivation Substrate Quality

The authors selected samples from 2 major substrate bag production bases located in Jiguan Village and Dabeigou Village of Jiguan Township for monitoring. According to the Soil

environmental quality risk control standard for soil contamination of agricultural land (Trial) (GB 15618—2018)[9], heavy metals and nutrient elements were tested (Table 3).

Table 2 Statistical testing result of main soil data in Jiguan Township

Test item	Sample 1	Sample 2	Sample 3	Sample 4	Limits[9]
pH	5.48	7.14	7.06	6.84	/
Pb (mg/kg)	21.19	12.56	14.49	20.46	≤140
Cd (mg/kg)	0.056	0.077	0.058	0.054	≤0.3
Cu (mg/kg)	9.21	17.28	27.30	16.02	≤100
Ca (g/kg)	4.53	23.46	29.68	12.63	/
K (g/kg)	19.67	16.06	10.63	19.95	/
Mg (g/kg)	6.25	16.11	19.61	10.90	/
P (g/kg)	0.58	0.86	0.82	1.13	/
Fe (g/kg)	25.31	55.01	42.14	41.52	/
OM (g/kg)	42.15	31.43	29.17	27.98	/
TN (g/kg)	1.69	1.01	1.38	1.54	/
TP (g/kg)	0.445	0.653	1.008	0.639	/
Cr (mg/kg)	58.17	64.80	107.54	71.81	≤150
Ni (mg/kg)	15.88	23.82	32.89	15.11	≤100
Zn (mg/kg)	60.20	57.16	64.76	79.74	≤200
Hg (mg/kg)	0.189	0.135	0.049	0.041	≤1.3
As (mg/kg)	13.26	5.40	7.91	13.37	≤40

Note: / indicates no corresponding standard limit.

Table 3 Statistical testing result of black fungus cultivation substrate in Jiguan Township

Test item	Jiguan Village	Dabeigou Village	Limits[9]
TOC (g/kg)	485.34	475.85	/
TN (g/kg)	5.33	6.94	/
TP (g/kg)	0.463	0.545	/
Ca (g/kg)	13.377	17.428	/
K (g/kg)	3.204	2.370	/
Mg (g/kg)	0.641	1.091	/
Fe (g/kg)	0.905	1.266	/
Cu (mg/kg)	4.361	6.232	≤50
Pb (mg/kg)	0.626	2.177	≤90
Cd (mg/kg)	0.044	0.134	≤0.3

Note: / indicates no corresponding standard limit.

The results showed that the concentrations of lead (Pb), cadmium (Cd), and copper (Cu) in the substrate bags ranged from 0.626 to 2.177 mg/kg, 0.044 to 0.134 mg/kg, and 4.361 to 6.232 mg/kg, respectively, all well below the national standard limits. Additionally, the substrate bags contained adequate levels of total organic carbon (TOC), total nitrogen (TN), total phosphorus (TP), and essential nutrient elements such as calcium, potassium, magnesium, and iron. These conditions provide a stable nutrient supply for black fungus growth, and the quality of the substrate bags meets the requirements for high-quality cultivation.

3.5 Water Conditions

The irrigation water sources for black fungus cultivation in Jiguan Township primarily consist of atmospheric precipitation and surface runoff. The cultivation areas are situated within traditional agricultural regions, with no industrial enterprises present in the watershed and no external sources of pollution.

The authors collected water samples from 4 sampling sites within the case area (Figure 11). According to the Standard for irrigation water quality (GB 5084—2021)[10], 21 elements and

ions were tested and analyzed (Table 4). The test results, provided by the Testing Department of the Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, showed that all water quality indicators exceeded national standards, indicating excellent water quality conditions that fully satisfy the irrigation requirements for black fungus cultivation.

Table 4 Statistical testing result of river water quality in Jiguan Township

Test item	Sample 1	Sample 2	Sample 3	Sample 4	Limits[10]
pH	7.21	7.05	7.53	6.75	5.5–8.5
CODcr (mg/L)	22.3	1.96	1.96	2.74	≤200
LAS (mg/L)	0.00021	ND	ND	0.00016	≤8
Cl^- (mg/L)	3.634	2.697	2.882	2.922	≤350
S^{2-} (mg/L)	0.0098	0.0058	0.0066	0.0067	≤1
TSC (mg/L)	84	56	55	38	≤1,000
Pb (μg/L)	1.789	0.462	0.440	0.413	≤200
Cd (μg/L)	0.071	0.090	0.043	0.058	≤100
Cr6+ (μg/L)	ND	ND	ND	ND	≤100
Hg (μg/L)	0.025	0.024	0.144	0.018	≤1
As (μg/L)	1.783	1.056	1.184	0.892	≤100
Ca (mg/L)	10.850	31.069	21.640	15.386	/
K (mg/L)	0.820	1.531	0.996	1.547	/
Mg (mg/L)	2.085	5.369	1.859	2.821	/
P (mg/L)	0.024	0.014	0.034	0.034	/
Fe (mg/L)	0.147	0.101	0.419	0.118	/
Cu (μg/L)	1.796	2.106	5.900	2.702	≤1,000
TSS (mg/L)	14	17	8	14	≤100
F^- (mg/L)	0.104	0.184	0.074	0.075	≤2
B (mg/L)	0.103	0.105	0.090	0.084	≤2
Ni (μg/L)	1.166	0.733	0.776	0.835	≤200
CN^- (μg/L)	0.104	0.122	0.079	0.095	≤500

Note: ND indicates not detected; / indicates no corresponding standard limit.

4 Product Characteristics Data

4.1 Basic Product Characteristics

The cultivation of black fungus in Wangqing Jiguan Township generally requires fruiting sites that are open, clean, well-ventilated, well-drained, protected from waterlogging, close to water sources, and easily accessible for transportation. Suitable locations include grasslands, flatlands, gentle slopes, or forested areas with approximately 60% sunlight and 40% shade, while low-lying areas should be avoided.

The quality characteristics of the black fungus are as follows: the fruiting bodies are bowl-shaped, measuring 5–8 cm in diameter and 1.0–1.3 mm in thickness. They have a thick, gelatinous texture, strong elasticity, and semi-transparency. The upper surface is a pure dark brown to black with a glossy appearance, while the underside is slightly grayish-white, with a clear distinction between the two surfaces. The product also demonstrates excellent rehydration properties, featuring large, uniformly sized pieces, well-expanded lobes with minimal curling, no rotten or damaged parts, and no unusual odor (Figure 13 and 14).

4.2 Product Quality

This study selected autumn black fungus samples from 6 core cultivation villages in Jiguan

Township: Jixing Village, Dabeigou Village, Jiguan Village, Yingbi Village, Jiming Village, and Huojiaying Village (Figure 11). The amino acid composition and quality indicators were analyzed by PONY Testing Group Shanghai Co., Ltd.

The amino acid analysis results (Table 5) revealed that samples from all six villages contained 16 common amino acids[11], with total amino acid contents ranging from 5.88 to 8.37 g/100g. Among these, glutamic acid was the most abundant (0.77–1.06 g/100g), followed by aspartic acid (0.68–0.92 g/100g). The samples included a full complement of essential amino acids and demonstrated a balanced amino acid profile.

Figure 13 Auricularia auricula (Jiguan Township)

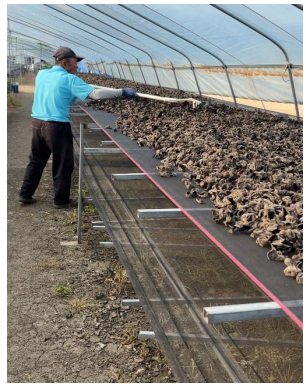

Figure 14 Black fungus drying (Jiguan Township)

Table 5 Statistical testing result of 16 amino acids in black fungus Unit: g/100g

Test item	Jixing Village	Dabeigou Village	Jiguan Village	Yingbi Village	Jiming Village	Huojiaying Village
Aspartic acid	0.71	0.83	0.78	0.92	0.68	0.74
Threonine	0.45	0.52	0.49	0.58	0.43	0.48
Serine	0.41	0.50	0.47	0.56	0.41	0.41
Glutamic acid	0.80	0.91	0.85	1.06	0.77	0.82
Proline	0.33	0.39	0.38	0.45	0.28	0.35
Glycine	0.33	0.43	0.39	0.47	0.32	0.35
Alanine	0.57	0.67	0.63	0.77	0.54	0.60
Valine	0.42	0.50	0.47	0.56	0.39	0.44
Methionine	0.010	0.038	0.030	0.030	ND	0.020
Isoleucine	0.22	0.28	0.26	0.31	0.20	0.22
Leucine	0.49	0.62	0.58	0.70	0.47	0.54
Tyrosine	0.20	0.23	0.19	0.23	0.20	0.24
Phenylalanine	0.33	0.42	0.38	0.45	0.32	0.34
Lysine	0.32	0.46	0.44	0.50	0.32	0.34
Histidine	0.20	0.22	0.22	0.26	0.19	0.21
Arginine	0.36	0.46	0.44	0.52	0.36	0.37
Total 16 amino acids	6.15	7.48	7.00	8.37	5.88	6.47

Note: ND indicates not detected.

According to the national standard for Wood ear (GB/T 6192—2019)[11], the product quality was tested by the Yanbian Korean Autonomous Prefecture Inspection and Testing Center. The results showed that all indicators exceeded the national standard requirements. The fruiting bodies were complete and uniform, naturally curled, and exhibited a pure color with good gloss. No moldy or insect-damaged fungus was detected, and the impurity content was 0 (national standard limit ≤0.5%) (Table 6).

Table 6 Statistical testing result of black fungus quality in Jiguan Township

Test item	Yingbi Village	Huojiaying Village	Jiming Village	Jiguan Village	Dabeigou Village	Jixing Village	Limits[11]
Mouldy ear	ND	ND	ND	ND	ND	ND	None
Insect earworm	ND	ND	ND	ND	ND	ND	None
Ear thickness (mm)	0.7	0.6	0.6	0.7	0.7	0.7	/
Impurities (%)	0.0 (no hair, metal debris, glass)	0.0 (no hair, metal debris, glass)	0.0 (no hair, metal debris, glass)	0.0 (no hair, metal debris, glass)	0.0 (no hair, metal debris, glass)	0.0 (no hair, metal debris, glass)	≤0.5
Dry-wet ratio	1:11.9	1:11.4	1:11.0	1:10.7	1:10.4	1:12.0	≥1:9
Moisture (%)	9.52	9.63	9.61	9.65	9.67	9.49	≤12.0
Ash (in dry mass) (%)	4.3	4.2	4.4	4.6	4.3	4.2	≤6.0
Total sugar (converted sugar) (%)	56.8	48.9	49.2	44.1	43.8	51.9	≥22.0
Crude protein (%)	11.0	10.8	12.6	12.8	12.5	10.9	≥7.0
Crude fat (%)	0.4	0.4	0.5	0.5	0.5	0.5	≥0.4
Crude fiber (%)	3.6	4.0	3.9	3.0	3.1	4.9	3.0–6.0
Pb (mg/kg)	0.061	0.056	0.18	0.17	0.21	0.082	≤1.0
Cd (mg/kg)	0.031	0.032	0.055	0.051	0.055	0.031	≤0.5
Inorganic arsenic (mg/kg)	0.073	0.065	0.057	0.081	0.077	0.051	≤0.5
Methylmercury (mg/kg)	0.0083	0.010	0.011	ND	0.091	0.013	≤0.1
DDT (mg/kg)	ND	ND	ND	ND	ND	ND	/
BHC (mg/kg)	ND	ND	ND	ND	ND	ND	/
Dichlorvos (mg/kg)	ND	ND	ND	ND	ND	ND	/
Ca (mg/kg)	490	456	358	426	395	457	/
Fe (mg/kg)	4.00	3.93	12.56	10.52	12.23	4.02	/
Mg (mg/kg)	167	211	203	221	212	151	/
P (mg/kg)	192	190	287	302	310	194	/
K (mg/kg)	1,014	1,038	1,126	1,149	1,158	930	/

Note: ND indicates not detected; / indicates no corresponding standard limit.

In terms of nutritional composition, black fungus is rich in protein, fat, carbohydrates, and various minerals. The dietary fiber content ranges from 29% to 31%, calcium from 110 to 130 mg/100g, iron from 9 to 11 mg/100g, magnesium from 140 to 160 mg/100g, phosphorus from 250 to 280 mg/100g, potassium from 1 to 3 g/100g, and selenium from 1.5 to 3 μg/100g, indicating balanced and abundant nutrition. The dried product has thick flesh and a dark color, while after rehydration, it exhibits good elasticity and glossiness. When consumed, it has a smooth and delicate texture with a distinctive natural fragrance, demonstrating excellent quality.

The concentrations of heavy metals, including lead, cadmium, inorganic arsenic, and methylmercury, were all well below the National food safety standard—maximum levels of contaminants in food (GB 2762—2022) limits[12]. Additionally, no pesticide residues such as DDT, BHC, or dichlorvos were detected, indicating that the product is safe and of reliable quality.

5 Historical, Cultural, and Industrial Management

5.1 Cultivation Management

The cultivation and management of Wangqing Jiguan black fungus adhere to standardized procedures throughout the entire production process[13,14]. A rigorous standardized system has been established, encompassing all stages, including strain selection and breeding, raw material substrate preparation, substrate bag production, mycelial cultivation and fruiting, field management, pest and disease control, harvesting and processing, and traceability management.

Priority is given to locally adapted, high-quality, cold-resistant strains. Qualified cultivation materials, such as hardwood broadleaf sawdust, are strictly regulated regarding composition ratios, moisture content, and bagging standards. Complete sterilization for adequate durations and aseptic inoculation procedures are rigorously implemented. During the mycelial growth stage, temperature, humidity, light exclusion, ventilation, and post-ripening of substrate bags are carefully controlled. After the mycelia mature, openings are made according to uniform specifications to stimulate fruiting. Based on the characteristics of open-air, full-light cultivation in Northeast China, scientific regulation is applied to light exposure, intermittent mist spraying, field drainage, and ventilation conditions during the fruiting stage[15,16].

Green pest and disease management practices, emphasizing agricultural and physical control methods, are consistently adopted, while the use of highly toxic pesticides is strictly prohibited or restricted. Harvesting is conducted at the appropriate maturity stage, followed by standardized sun drying or low-temperature drying, graded dehydration, and clean storage and packaging. Additionally, a comprehensive production record system has been established to ensure full-process traceability. Strict controls are enforced against the use of prohibited raw materials, insufficient sterilization, illegal pesticide application, contamination by miscellaneous fungi, and improper drying practices, thereby comprehensively ensuring the safety and quality of black fungus products.

Based on the growth conditions and cultivation experience of wild black fungus, sawdust is selected as the primary substrate material. Wheat bran serves as a supplementary filler and nutrient source, soybean meal powder provides minerals and trace elements, gypsum powder acts as a stabilizing and shaping agent, and lime is used to regulate the substrate's pH. The proportions of the substrate components are as follows: sawdust 90%–95%, wheat bran 2%–4%, soybean meal powder 2%–3%, gypsum 0.8%–1.2%, and lime 0.6%–0.8%. The wood materials primarily originate from local birch and Mongolian oak trees in the Changbai Mt. area.

Each discarded cultivation bag weighs approximately 0.4 to 0.5 kg after use. There are 4 primary methods for recycling discarded substrate bags: (1) use as household fuel; (2) returning spent substrate residue to farmland as fertilizer; (3) recycling by enterprises; and (4) biomass power generation. The recycling price for discarded substrate bags is approximately 240 to 260 CNY per ton.

5.2 Cultural History of Wangqing Jiguan Black Fungus

The history of harvesting and consuming black fungus in Jiguan Township, Wangqing County, dates back many centuries. As early as 73 BC, the Book of Rites (Liji) recorded the phrase "food added to the common, ashamed of the Zhitong", in which "Zhitong" referred to mushrooms and fungal products. In the 530s AD, the Northern Wei agricultural scientist Jia Sixie described culinary methods for black fungus in the Qimin Yaoshu. During the Tang Dynasty, SU Gong first documented artificial cultivation techniques for black fungus in the Tang Bencao Zhu, stating: "Mulberry, locust, cypress, elm, willow, these kinds of trees can

grow agaric. Boiled rice slurry porridge, spread on the branches of these trees, and then covered with grass, the fungus naturally grew out", meaning that black fungus could be cultivated on various hardwood trees by applying a cooked porridge-like paste and covering it with grass.

The history of black fungus cultivation in Wangqing County dates back to 1862, during the Tongzhi reign of the Qing Dynasty. According to the Wangqing County Annals, local residents gradually developed diversified livelihood strategies beyond farming, hunting, and medicinal herb collection, including "caiying" (black fungus cultivation) and "bangchuiying" (ginseng cultivation).

The cultivation of black fungus in Jiguan Township has grown from an initial annual planting of 1.2 million bags to 30 million bags in 2025 (the highest total planting scale in the township's history reached 48 million bags in previous years). The industry now encompasses all administrative villages, and the number of cultivation households has increased from more than 60 to over 750. An ecological circular industrial chain has been established, integrating strain research and development, substrate bag production, cultivation base construction, product processing, brand packaging, logistics distribution, and waste substrate treatment, making black fungus the township's pillar industry.

In 2019, the township hosted the China Wangqing Black Fungus Industry Development Conference. On July 4, 2020, Jiguan Township also held a Black Fungus Festival featuring activities such as performances by the Xiangmao Dance Art Troupe, black fungus picking competitions, black fungus packaging contests, visits to product and art exhibition areas, and a Korean ethnic folk event that included a "thousand-person bibimbap banquet".

5.3 Changes in Population Structure and Industrial Development

From 2014 to 2025, the population of Jiguan Township exhibited a continuous decline. The rural population decreased from 8,510 to 7,361, a reduction of 1,149 people, representing a 13.50% decrease. This corresponds to an average annual decrease of 104.5 people and an average annual decline rate of 1.23%.

The working-age population decreased from 5,531 to 4,722, a cumulative reduction of 809 people, representing a decline of 14.63%. The proportion of the labor-force population declined slightly from 64.99% to 64.15%, a decrease of 0.84 percentage points[2]. This reduction in the total labor supply has had a noticeable impact on agricultural production and rural development (Table 7).

The urban-rural population structure exhibited a pattern of "rural increase and urban decrease", with the urbanization rate declining contrary to the overall trend. The proportion of the rural population in the total population rose from 92.32% to 93.59%, an increase of 1.27%. Meanwhile, the urban population decreased from 708 to 504, a reduction of 204 people or 28.81%, and its share of the total population declined from 7.68% to 6.41%. The rate of decline in the urban population was 1.96 times greater than that of the total population, indicating a continuous contraction of the urban population size.

The gender composition of the population remained relatively stable. The male population decreased from 4,744 to 4,045, a decline of 14.73%, while the female population decreased from 4,474 to 3,820, a decline of 14.62%, maintaining a balanced gender ratio.

Since the implementation of the rural revitalization strategy, the black fungus industry in Jiguan Township has attracted investments totaling 69.0966 million CNY. 5 standardized substrate-bag factories have been established with a combined investment of 22.7616 million CNY, producing 200,000 substrate bags daily, with most wood and sawdust

[2] Data source: Jiguan Township Government.

Table 7 Statistical of rural population of Jiguan Township over the years

Year	Rural organizations of gross roots		Rural households and population		
	Village committee	Villagers' groups	Rural households	Rural population (persons)	Population within working age (persons)
2014	13	64	2,995	8,510	5,531
2015	13	64	2,790	7,925	5,167
2016	13	64	2,780	7,914	4,610
2017	13	64	2,761	7,840	4,896
2018	13	64	2,755	7,825	5,491
2019	13	64	2,722	7,740	5,413
2020	13	64	2,735	7,777	5,055
2021	13	64	2,692	7,644	4,968
2022	13	64	2,684	7,623	4,910
2023	13	64	2,640	7,498	4,822
2024	13	64	2,617	7,431	4,810
2025	13	64	2,592	7,361	4,722

materials sourced from Liaoning Province. 1 strain-production factory was constructed with an investment of 9.25 million CNY, boasting an annual production capacity of 1.5 million strain bags. 3 standardized incubation workshops were established with a total investment of 29.5 million CNY, capable of cultivating 8 million bags annually. 4 black fungus cultivation bases were developed with a total investment of 7.515 million CNY, all situated on basic farmland, with an annual placement capacity of 2.7 million cultivation bags. Additionally, an edible fungus research institute was founded with an investment of 70,000 CNY. In 2019, the "Jiguan Qingwa" black fungus brand was officially registered and subsequently obtained QS certification, Green Food certification, and Geographical Indication Product protection.

By 2025, the industry had achieved a total production of 1.8 million kg of black fungus, with an annual output value of 100 million CNY and net profits approaching 36 million CNY. The average household income increased by 48,000 CNY, providing strong support for regional economic development and farmers' income growth.

At present, Wangqing black fungus has become a key pillar industry in the county's agricultural sector. The county currently hosts 17 provincial- or prefecture-level leading agricultural industrialization enterprises, 71 standardized substrate-bag factories, 116 specialized cooperatives, and 10 family (specialized) farms. The annual cultivation scale remains stable at 450 million bags, producing 23,000 t of dried black fungus with an output value of 3.4 billion CNY, supporting approximately 30,000 farming households involved in related industries.

During the poverty alleviation campaign, the industry increased the per capita income of 14,369 impoverished individuals from 8,356 households by more than 500 CNY through 3 main approaches: substrate-bag production, cultivation and maintenance, and employment opportunities. In the rural revitalization stage, an innovative "enterprise + village collective + farmer household" model was introduced, whereby cooperatives or leading enterprises undertook cultivation and management on behalf of households with limited or no labor capacity. In 2024, this model helped 1,784 formerly impoverished individuals from 1,137 households increase their per capita income by more than 400 CNY, demonstrating significant industrial spillover and driving effects.

5.4 Ecological Environment Traceability for Wangqing Jiguan Black Fungus

To ensure traceability of the black fungus growth environment and production process, in April 2025, the Market Supervision Administration of Wangqing County, in collaboration with the Government of Jiguan Township, installed the GIES ground station in the core

black fungus cultivation areas (Figure 15, 16).

The ground station is low-power Internet of Things (IoT) sensing devices capable of automatically acquiring, identifying, and transmitting ecological and environmental data, including meteorological conditions, air quality, soil conditions, water quality, vegetation, phenology, and pest and disease information. Additionally, clear responsibilities for equipment protection and operational management have been established.

Figure 15 GIES ground station
(Photo taken by WANG Yichun on May 24, 2025)

Figure 16 QR code of GIES ground station in Jiguan Township

6 Discussion and Conclusion

The unique topography and landforms of Jiguan Township, combined with its favorable climatic conditions—including abundant sunlight, suitable temperature, and humidity—as well as high-quality soil and water resources, have collectively fostered the production of high-quality black fungus with distinctive geographical indication characteristics. By leveraging local ecological resources, this case has developed high-value-added agricultural cultivation and deep-processing industries, while also nurturing leading agricultural industrialization enterprises. Consequently, the industry has achieved significant economic benefits, including an annual output value of 100 million CNY and an average household income increase of 48,000 CNY, in addition to creating substantial employment opportunities. These accomplishments have played a crucial role in mitigating population outflow and promoting rural revitalization.

At the same time, the development model established in Jiguan Township—characterized by "ecological conservation+standardized production+brand building+integration of primary, secondary, and tertiary industries"—offers valuable practical experience for developing distinctive agricultural products and promoting the coordinated advancement of ecological and economic development in similar regions throughout China.

Future research could further deepen the analysis of the coupling relationships between black fungus growth and ecological environmental factors, optimize cultivation technologies, and enhance industrial ecological benefits. Additionally, greater efforts should be made to explore brand culture and strengthen market promotion to expand into high-end consumer markets and foster higher-quality, more sustainable industrial development.

Author Contributions

Ye, Y. H., Lu, P., Leng, L. and Chen, S. B. were responsible for the overall design of the data set and the first draft of the data paper; Wang, Y. C. and Ye, Y. H. were responsible for the collection and testing of samples such as soil, water and bacteria. Zhao, Y., Li, E. H., Gao, M. X., Wang, J. S., Gao, B., Wang, Y. C., Wu, D. provided and processed real-time monitoring

data; Song, Y. B. provided social and economic development and demographic data of Jiguan Township; Wang, B., Lin, Y., Xia, W. Q., Wei, Y. C., Han, Y., Yao, F. J. collected and provided the key data of black fungus planting management. Ye, Y. H. completed the final draft of the paper.

Acknowledgments
The authors sincerely thank Professors Liu, C., Wang, Z. B., and Song, X. F. for their guidance. We also express gratitude to the leaders of the Market Supervision Administration of Wangqing County and other related departments for their strong support.

Conflicts of Interest
The authors declare no conflicts of interest.

References

[1] Mu, J. H. Research on the EU geographical indication system for agricultural products and its enlightenment [J]. *Quality and Safety of Agricultural Products*, 2021(2): 88–92.
[2] Dong, Y. N., Gu, Y., Yang, K. Z. Agricultural product brands, market integration and agricultural income growth [J]. *Journal of Capital University of Economics and Business*, 2021, 23(1): 70–80.
[3] Pan, S. J. Let geographical indications boost rural revitalization [N]. Fujian Daily, 2021-02-28(001).
[4] Han, X. The industrial transformation road of Wangqing Auricularia auricula [J]. *Agricultural Products Market*, 2019(11): 30–32.
[5] Li, J. Y., Chi, W., Liu, B., *et al*. Analysis on the current situation of industrial economy and comparison of production benefits of Auricularia auricula in China [J]. *Edible Fungi*, 2019, 41(6): 6–8+10.
[6] Hou, R. M. Analysis on the economic value and processing utilization of edible fungi [J]. *Agricultural Products Processing*, 2018(11): 74–76.
[7] Ye, Y. H., Zhao, Y., Li, E. H., *et al*. GIES case dataset on Wangqing black fungus facility agriculture mountain valleys in Jiguan Township [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2026. https://doi.org/10.3974/geodb.2026.02.07.V1.
[8] GCdataPR Editorial Office. GCdataPR data sharing policy [OL]. https://doi.org/10.3974/dp.policy.2014.05 (Updated 2017).
[9] Ministry of Ecology and Environment of P. R. China, State Administration for Market Regulation. Soil environmental quality risk control standard for soil contamination of agricultural land (Trial) (GB 15618—2018) [S]. Beijing: China Environment Publishing Group, 2018.
[10] Ministry of Ecology and Environment of P. R. China, State Administration for Market Regulation. Standard for irrigation water quality (GB 5084—2021) [S]. Beijing: China Environment Publishing Group, 2021.
[11] State Administration for Market Regulation, National Standardization Administration. Wood ear (GB/T 6192—2019) [S]. Beijing: Standards Press of China, 2019.
[12] National Health Commission of P. R. China, State Administration for Market Regulation. National food safety standard—maximum levels of contaminants in food (GB 2762—2022) [S]. Beijing: Standards Press of China, 2022.
[13] Huang, R. X., Li, S. R., Huang, S. M., *et al*. Standardized cultivation technology of full-light ground planting with small holes for Auricularia auricula in the Changbai Mountain area [J]. *Jilin Vegetables*, 2017(7): 31–33.
[14] Yao, F. J., Zhang, Y. M., Chen, Y., *et al*. Brief analysis of two main cultivation modes of Auricularia auricula in China [J]. *Edible and Medicinal Fungi*, 2011(3): 38–39.
[15] Wang, Y., Ji, S. J., Wang, Z. H., *et al*. Auricularia auricula new variety 'Jiyaner No. 1' [J]. *Acta Horticulturala Sinica*, 2025 (52): 139–140.
[16] Fu, J., Yang, Y. C., Zheng, H. C. The effect of tending timber on the quality and industrial development of Auricularia auricula [J]. *Forestry industry*, 2025(62): 95–100.