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Current Development Situations of *Ziziphus Jujuba* Industry in South Xinjiang and Recommendations

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Abstract Through surveying current development situations and existing problems of planting and processing of *Ziziphus jujuba* in south Xinjiang, this paper discussed planting, processing mode of *Ziziphus Jujuba* in south Xinjiang and development direction of enterprises in *Ziziphus Jujuba* production. It is expected to ensure and increase quality and sales volume of *Ziziphus Jujuba* and promote sound and sustainable development of *Ziziphus Jujuba* industrial chain in south Xinjiang.

Key words South Xinjiang, *Ziziphus Jujuba*, Current development situations, Equipment deployment, Recommendations

With high nutritive value and health care value and good reputation of natural vitamin capsule, *Ziziphus Jujuba* is high quality nourishing fruit. Apart from higher content of sugar, protein, fat, iron, phosphorus and calcium than ordinary fruits, *Ziziphus Jujuba* also contains 18 types of essential amino acids. In addition, it is believed to alleviate stress, and is traditionally used for antifungal, antibacterial, antiulcer, anti-inflammatory, sedative, antispastic, antifertility/contraception, hypotensive and antinephritic, cardiogenic, antioxidant, immunostimulant, and wound healing properties. South Xinjiang has a long history of *Ziziphus Jujuba* planting, but large-scale planting started only from 2008. In 2009–2011, it developed rapidly and reached the climax in the period of Twelfth Five-year Guideline. In recent years, with rapid development of the *Ziziphus Jujuba* industry, the *Ziziphus Jujuba* planting area in south Xinjiang rapidly increases and has become a pillar industry of south Xinjiang and becomes new highlight of rural economic growth and increase of farmers' income^[1]. However, for the present situation, there are still many problems in *Ziziphus Jujuba* industry of south Xinjiang. These problems are restricting quality and sales volume of *Ziziphus Jujuba*. It is required to carefully study how to realize sound, stable and sustainable development of *Ziziphus Jujuba* industry, ensure quality of *Ziziphus Jujuba*, and realize sales of *Ziziphus Jujuba* at both home and abroad.

1 Current development situations of *Ziziphus Jujuba* planting in south Xinjiang

1.1 Planting area and varieties *Ziziphus Jujuba* is a promising economic forest tree species. The *Opinions about Accelerating Development of Ziziphus Jujuba Industry in the Construction Corps* issued by Xinjiang Production and Construction Corps clearly stat-

ed that by 2010, the *Ziziphus Jujuba* planting area reached 80 000 hm²; by 2012, it completed transformation of low yield parks, and the high efficient standardized *Ziziphus Jujuba* parks reached 13 333 hm², and total yield of *Ziziphus Jujuba* reached 0.8 million tons^[2]. By now, the planting area of *Ziziphus Jujuba* is respectively: Agricultural Division No. 1: 43 000 hm²; Agricultural Division No. 2: 20 000 hm²; Agricultural Division No. 3: 28 000 hm²; Agricultural Division No. 14: 130 000 hm².

At present, *Ziziphus Jujuba* varieties planting in south Xinjiang mainly include local long *Ziziphus Jujuba*, round *Ziziphus Jujuba* and small Qeshqer *Ziziphus Jujuba*; introduced Junzao, Huizao, Zanzhuang jujube, Huping jujube, Lingbao jujube, Xinzheng huizao, and Jinsi small jujube. To develop fresh jujube market, it introduced new varieties, such as Jinchang No. 1, winter jujube, and pear jujube in recent years^[3]; in the production, Junzao, Huizao, and Zanzhuang jujube have higher yield and quality and are favored by jujube planters. These varieties are mainly sold in dry form and only a small portion is sold in fresh form (as listed in Table 1).

1.2 Orchard construction types and planting modes *Ziziphus Jujuba* orchard construction in south Xinjiang mainly adopts transplantation and direct seeding types^[4]. Some old jujube orchards purchase seedlings from other areas and then transplant seedlings; some orchards are built through transplanting 3–4 years old jujube seedlings. Since the survival rate of transplantation methods is low, most south Xinjiang areas adopt direct seeding method. For direct seeding method, it can harvest jujube after 2 or 3 years. Wild jujube seeds of direct seeding are mainly purchased from Shanxi, Shaanxi, Hebei and Henan provinces. Jujube orchards adopting direct seeding method generally reach the best fruiting period in 6 or 7 years.

Due to difference in climate, soil and environment, there is no unified planting mode in agricultural divisions and regiments of south Xinjiang. Jujube orchards in different areas have different spacing in the rows. Even in the same jujube orchard, with growth

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of jujube, the spacing in the rows will change constantly till grow to the best fruiting period. At the early stage of building jujube orchard, it is recommended to adopt short and dense cultivation method to ensure higher yield. For example, when building orchard using direct seeding method, the spacing in the rows is 2m x 0.5m. With increase in jujube tree body, the spacing in the rows can be adjusted to 2m x 1m, 2m x 2m, and 4m x 2m. Common spacing in the rows includes 1.5m, 2.0m, 3.0m, 4.0m and 4.5 m. The stock spacing in the rows for direct seeding is generally 10

–50cm, including temporary plants and permanent plants. With growth of jujube trees, it is recommended to gradually cut down temporary plants to increase the spacing in the rows, and keep the permanent plants to form the jujube orchard of the best fruiting period^[5]. As shown in Fig. 1, we found three representative jujube planting modes. Fig. 1 – a is single row planting mode; Fig. 1 – b is double row planting mode, Fig. 1 – c is wide-narrow tall-short staggered mode.

Table 1 Current situations of major *Ziziphus Jujuba* varieties in south Xinjiang

Name	Use	Source	Main distribution areas
Junzao jujube	Dried, fresh, processed	Shanxi	Agricultural Division No. 1, No. 2, and No. 14
Huizao jujube	Dried, fresh	Henan	Agricultural Division No. 1, No. 2, and No. 3
Zanhuang jujube	Dried, fresh, processed	Hebei	Agricultural Division No. 1 and No. 2
Hami jujube	Fresh	Xinjiang	Agricultural Division No. 13
Jinchang No. 1	Dried, fresh	Henan	Agricultural Division No. 3

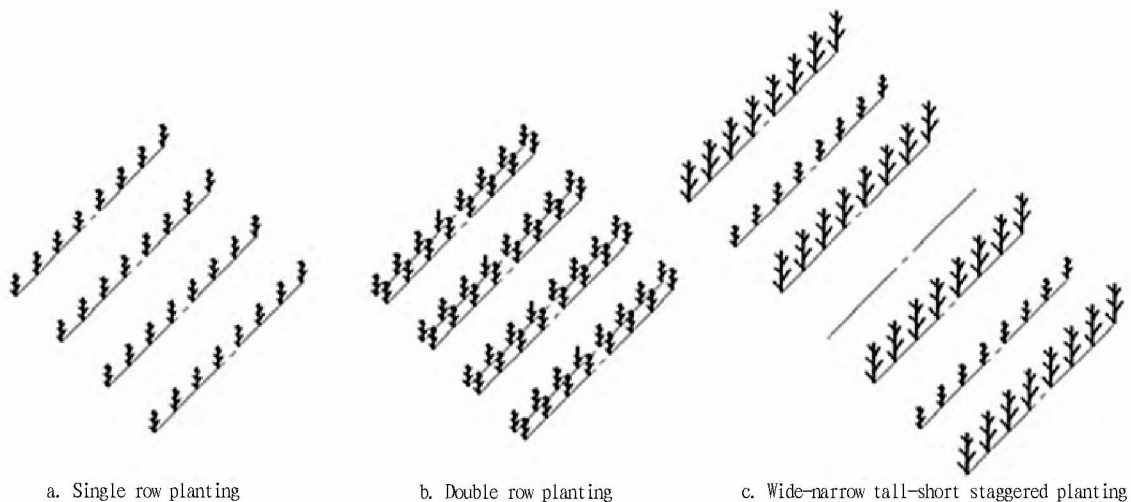


Fig. 1 Jujube planting modes

1.3 Field management of jujube orchards Through survey, we found that different divisions in south Xinjiang have different planting area and different number of workers, and each worker manage different area of jujube, generally 1.0–4.3 hm². For example, Regiment No. 12 of Agricultural Division No. 1 is 1.3 hm²/household, Regiment No. 31 of Agricultural Division No. 2 is 1.0–1.3 hm²/household, Regiment No. 44 of Agricultural Division No. 3 is 1.3–3.0 hm²/household, Regiment No. 224 of Agricultural Division No. 14 is 3.0–4.3 hm²/household.

1.3.1 Irrigation. South Xinjiang belongs to temperate arid climate zone, and the surface evaporation capacity is much higher than rainfall. For example, the reclamation area of Agricultural Division No. 1 has annual rainfall of 40.1–82.5 mm; the reclamation area of Agricultural Division No. 2 has annual rainfall of 23.3–75.1 mm; the reclamation area of Agricultural Division No. 3 has annual rainfall of 38.3 mm; the reclamation area of Agricultural Division No. 14 has annual rainfall of 35.0–48.5 mm^[6]. Dry and windy climate makes most divisions and regiments

of south Xinjiang adopt drip irrigation, only few divisions and regiments do not have drip irrigation condition and have to adopt flood irrigation. In dry desert areas, it needs little water for survival of jujube trees. Planting jujube can save water, check winds and fix drifting sand; if to ensure yield and quality of jujube, jujube planting does not save water.

1.3.2 Fertilizer application. In fertilizer application for jujube orchards, different areas and different years have different weight and type of fertilization application. For example, Regiment No. 31 of Agricultural Division No. 2 adopts drip irrigation for stock wild jujube orchards, does not apply nitrogen fertilizer after 6 months (to prevent excessive nitrogen fertilizer leading to difficult to pass the winter), but applies 225 kg/hm² potash fertilizer and 300 kg/hm² phosphorus fertilizer. Company No. 4 of Regiment No. 12 of Agricultural Division No. 1 adopts ditching machine to apply fertilizer, mainly base manure. Regiment No. 44 of Agricultural Division No. 3 applies organic fertilizer (sheep manure) 52.5 t/hm², then applies N, P, and K fertilizer 3.75–4.5 t/hm²,

finally applies special-purpose fertilizer 3.75–4.5 t/hm², applying fertilizer for three times (the first two times adopt ditching application, and the final time adopts surface application), finally adopts infiltration irrigation. Regiment No. 224 of Agricultural Division No. 14 generally adopts drip irrigation method for its model jujube orchard, organic fertilizer is applied by ditching method, and it applies fertilizer 8 times in a whole year (two times in April-July, and no application in other times).

1.3.3 Plant protection. To prevent and control plant diseases and insect pests of jujube trees, divisions and regiments of south Xinjiang mainly spray pesticide using tractor driven machine.

1.3.4 Jujube tree pruning. The mechanization level of jujube tree pruning is low. Generally, jujube trees are pruned manually, including winter pruning and summer pruning. Different areas have different jujube tree pruning skills. For example, Regiment No. 31 of Agricultural Division No. 2 adopts "three tens" and "three severs" pruning skills, while Regiment No. 12 of Agricultural Division No. 12 adopts "three-five-nine" pruning skills. The above pruning skills are generally used in the next year after grafting, while after orchards reach the best fruiting period, it generally adopts light pruning skill. Only tender top-picking of jujube is required.

1.3.5 Drying and harvesting of jujube fruiting. In normal years, water content of mature jujube is high, and jujube needs drying in fruiting period. Jujube generally can be harvested after frosting. At this time, the water content of jujube is about 30–40%, jujube becomes dry or semi-dried jujube. During fruiting and drying period, 15–20% jujube will fall off, and the rest jujube will not grow in trees but will still keep accumulation of sugar. Therefore, dried jujube will have higher quality than those falling off or harvested in advance^[7]. As to whether drying in fruiting period will influence yield of jujube in next year, many agronomists think it will not influence the yield of jujube in the next year as long as water and fertilizer are managed well. However, drying in fruiting period is greatly influenced by climate condition. For example, in 2010, jujube in south Xinjiang suffered severe rain disaster in harvesting period, numerous jujubes become rotten or cracked, the yield was only a half in normal years, seriously influencing economic benefits of jujube farmers^[8]. Besides, water of jujube harvested in rain disaster contains higher water (about 40–50%). In jujube processing and storage, it brings higher difficulty and pressure to enterprises. Currently, regiments and divisions of south Xinjiang mainly adopt manual harvesting of jujube (employing workers to knock down and pick jujubes), the efficiency is relatively low. After harvesting, jujubes are purchased and sold without separation or classification, and are transported and stored by purchasers.

1.4 Distribution of jujube orchard income To reduce burden of farmers, most orchards are built by construction divisions and regiments. Seeds for direct seeding, seedlings for grafting and expenses of grafting are assumed by construction divisions and regiments. Farmers are only responsible for management. At the ear-

ly stage of orchard construction, all income from planting jujube trees can be owned by farmers, to safeguard income of farmers and realize stable transition and development of jujube planting. When harvesting jujubes, distribution of orchard income is generally managed in open and intensive types. For example, Regiment No. 44 of Agricultural Division No. 3 settles the orchard contract fee in the form of turnover of jujubes after harvesting jujubes. In normal years, orchards hand over dry jujube 375 kg/hm² after one year of grafting, 750 kg/hm² after two years of grafting, 1200 kg/hm² after three years of grafting, and the rest jujubes can be disposed by farmers freely. Such method is open management mode. Different from Regiment No. 44 of Agricultural Division No. 3, Regiment No. 224 of Agricultural Division No. 14 adopts intensive management. When harvesting jujubes, all jujubes will be sold by the regiment, and the regiment sets the minimum protection price according to harvest condition. Purchasers from other places are distributed with orchards randomly in way of drawing lots. Before purchasing, purchasers should pay certain amount of guarantee and 2 yuan/kg resource management fee for the regiment. For the income from sales of jujubes, the regiment will deduct 20% of the first class jujube as contractual fee and the rest will be returned to farmers.

2 Current processing situations of jujubes in south Xinjiang

Most jujubes in south Xinjiang are processed by specialized enterprises, and only a small portion is processed by jujube farmers and small workshops. Processing of jujubes generally includes 10 processes: purchasing half-dried jujubes, naturally drying, primary classification, separation and foreign substance removal, washing, processing, cooling disinfection and moisture regain, secondary classification, inspection and packaging^[9]. The above processes and skills are established through many years of exploration of jujube enterprises and farmers. The present jujube processing processes are relatively mature and can basically solve problems of jujube processing in practical application. Major reasons for adopting the above processes are as follows.

2.1 Drying processing Fresh jujubes contain much water (generally about 70%), the respiratory strength is high, so direct harvesting easily leads to rot, even in freezer, it can not guarantee the quality completely^[10]. Therefore, jujube processing enterprises are unwilling to purchase fresh jujubes, but directly purchase semi-dried jujubes from farmers or farms, to shorten storage time of freezing and processing cycle of drying fresh jujubes, and accordingly reduce the cost. Enterprises only purchase jujubes containing water less than 50%, so fresh jujubes should be dried on trees. Besides, drying on trees is also a further mature process of jujubes. In this process, sugar in jujubes will gradually accumulate, which is favorable for sugar accumulation in dry jujubes.

2.2 Naturally drying with the aid of solar energy After picking from trees, semi-dried jujubes also easily become rotten or decayed. Therefore, jujubes must be rapidly dried for the purpose

of storage. Semi-dried jujubes purchased by enterprises have great difference in water content due to time and climate influence. After naturally drying, the water content becomes basically uniform (about 30%).

2.3 Analysis of processing technology of drying room

South Xinjiang usually adopts drying room to dry jujubes. Every year, jujubes are harvested in a short time. Since drying room has limited processing capacity, jujubes can not be processed completely in a short period. In reality, jujubes are dried and processed at the same time. Processing time of drying room will decrease with reduction of initial water content of jujubes. Semi-dried jujubes have water content of about 50% and need drying about 20 hours; slightly drier jujubes need drying 12 hours; nearly dry jujubes need drying 6–8 hours, such jujubes take up the major part (more than 80%). Processing in drying room mainly has three functions: (i) conversion process of reducing sugar, commonly called curing, this process takes about 30–45 minutes and needs proper temperature and humidity; (ii) dehydration process, reducing water content of jujubes from 30% to 23–26%; (iii) softening process, to improve taste and flavor.

2.4 Analysis of microwave processing technology Some jujube enterprises in south Xinjiang adopt microwave processing technology to dry jujubes. In terms of microwave drying, the heat is generated by directly transforming the electromagnetic energy into kinetic molecular energy^[11]. Energy directly couples with water in material. After heating, water will rapidly gasify and form higher pressure. Both temperature of material and pressure of water reduce from inside to outside, so the drying is rapid. At present, microwave power for processing jujubes is generally 50–150 kW at temperature of 55–65°C, and the conveying speed of conveying belt is generally 3–5 m/min. According to difference of jujubes in water content, the processing time is about 5–8 min. Jujubes processed by microwave can keep fragrance of fresh jujubes and have better taste than those dried in drying rooms.

3 Existing problems in *Ziziphus Jujuba* industry in south Xinjiang

3.1 *Ziziphus Jujuba* planting and management are extensive and have not realized standardized production

South Xinjiang is area where people of the minority nationalities live in compact communities. Due to historical and natural conditions, rural economy develops slowly. In addition, farmers' comprehensive quality is low, orchard management is extensive, and input is insufficient. It pays little attention to extension and application of new technologies, and standardized production knowledge is deficient. In South Xinjiang, jujube planting lacks centralized and unified management, and has no large-scale modern jujube production bases. As a result, jujube planting is greatly inconsistent with planting scale and industrialization level. It fails to form scale advantage, the per unit area yield is low, and comprehensive benefit of jujube is also low.

3.2 Automation level of processing equipment is low Since

temperature and humidity of baking room are not consistent, it will lead to inconsistent water content of jujubes after processing. Some jujubes are too soft, while some jujubes are excessively hard. In addition, the water content of single jujube is not consistent, leading to half soft and half hard of jujubes and influencing taste. After processing in baking rooms, jujubes color will become inconsistent inside^[2]. Some processed jujubes will have brown stain in the side far away from jujube carpopodium, while the other side has no serious brown stain. This may be resulted from inconsistent sugar content due to inconsistent maturity of jujube sides. In the brown stain side, the maturity and sugar content are higher and sugar content is inverted and the caramel reaction will occur.

In existing traditional baking room processing process, all processes are manually processed. In the control process, the control precision of temperature and humidity parameters is low, control parameters lag behind seriously. Besides, it still uses dry bulb thermometer or wet bulb thermometer to convert relative humidity, the technical level is relatively backward. In addition, baking room only has one humidity and temperature monitoring point, fails to accurately reflect changes of temperature and humidity inside the baking room and has large system error. The above defects of baking rooms lead to poor homogeneity of jujubes after drying, and the quality is uneven, so it greatly limits improvement of processing quality of jujubes.

3.3 The rate of loss during transport and storage is high

At present, jujube processing industry in south Xinjiang has not really solved key problems of jujube loss. The loss of jujubes is still very serious. In normal condition, the production rate of jujubes remains 50–60%. In special years, the production rate is only 30%. For example, Desert Jujube Industry of Agricultural Division No. 1 had production rate of jujubes only 55% in 2009, and only 28% in 2010. On the whole, the loss of jujubes is very serious^[12]. Semi-dried jujubes have to undergo transport, storage, and drying steps before entering the baking rooms or microwave processing, leading to rot, decay and loss of numerous jujubes. Surveys have shown that there is about 10% loss of jujubes after transport and storage. After naturally drying and classified separation, the rate of loss reaches 20–30%. Therefore, the production rate of jujubes keeps low level all the time, leading to product price remaining high.

3.4 There are relatively few finely and deeply processed products

In recent years, the jujube processing industry in south Xinjiang develops rapidly, but it is mainly rough processing and the repetition problem is serious, and it is difficult to produce brand effect. At present, Xinjiang Production and Construction Corps have more than 10 jujube leading enterprises, and tens of small processing enterprises, but these enterprises are mainly rough processing enterprises, the technical level is low, production scale is small, the jujube processing capacity only accounts for 20% of total yield, and 80% jujubes are sold in the form of primary products^[13]. Most jujube processing enterprises still adopt traditional technologies to treat harvested jujubes. There is nearly

no new and high technology, and the added value of jujubes is relatively low. For extraction of substances jujubes with nutrition and medical value, there is still no in-depth research and development. The development of deep processing products of jujubes lags behind, leading to unfavorable condition of famous and high quality brands. At the same time, weak research and development of new products influence in-depth development of jujube processing.

4 Recommendations for development of *Ziziphus Jujuba* industry in south Xinjiang

4.1 Enhancing standardized production of *Ziziphus Jujuba* industry All areas of south Xinjiang should select suitable jujube variety in accordance with standardized production requirement. In the production and processing of *Ziziphus Jujubas*, it is recommended to implement Good Agricultural Practice (GAP), Good Production Practice (GPP) and Hazard Analysis and Critical Control Points (HACCP), strictly control use of input products, and resolutely put an end to the use of high remains of pesticide especially in prevention and control of plant diseases and insect pests, and strictly prevent various types of pollution in processing of jujube products^[14]. Besides, it is recommended to establish *Ziziphus Jujuba* quality management system, raise quality and safety awareness of government at all levels, and the awareness of participation of international competition, gradually establish suitable quality standard system, inspection and test system, and certification system suitable for international forest and fruit products.

4.2 Making modern transformation on the basis of existing baking rooms It is recommended to make modern transformation of traditional baking rooms, to realize automatic control of baking rooms. The transformation must closely combine with existing production situations of enterprises, put up real time automatic temperature and humidity monitoring system, raise automation level of original facilities in baking rooms, so as to improve quality of jujube processing. When baking rooms realize automatic control, it is required to ensure even drying of jujubes, and control reasonable inversion of sugar, so as to obtain higher jujube quality.

4.3 Studying rapid treating technologies and facilities for harvested jujubes After jujubes are harvested, they need to undergo transport, storage, and drying. In these processes, the loss of jujubes is serious. Especially in overcast and rainy days, jujubes are easily cracked, rotten and decayed. Jujubes are usually directly dried without sterilization after harvesting. The enzyme activity and bacterial colony are high, and sugar and organic matters in jujubes will be consumed by higher strength breathing action. The longer the drying time, the higher loss of jujubes, and the lower production rate of dried jujubes. Therefore, it is necessary to develop rapid treating technologies and facilities, to solve the problem of high rate of loss during transport, storage and drying. The use of such technology and facility should ensure that

short-time treatment can remove various enzymes and bacterial ovum, prevent rotting and decaying of jujubes during storage, and reduce loss of jujubes in the breathing process.

4.4 Researching and developing jujube products with high added value Xinjiang is situated in inland and has a long distance from east coastal areas. High cost for transportation of products of Xinjiang requires that it must orient towards high end market, increase added value, and reduce marginal benefit of transport cost. At present, most jujube processing enterprises process dried jujubes, which are primary products. Only few enterprises deeply process jujubes. Therefore, it is recommended to carry out research and development of high added value products. This not only solves the problem of high transport cost, but also solves problem of treating such unacceptable jujubes as cracked, rotten and decayed jujubes, which play a great role in increasing economic benefits.

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