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Characteristics and quality of leaves of different clones of mulberry in the Mu Us Desert

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Abstract: *Mulberry is an important economic tree species. Both leaves and fruits have important economic value, Due to the dry and cold climate conditions in the Mu Us desert, the varieties suitable for cultivation in the Mu Us desert are unique. There are a large area of wild mulberry trees naturally distributed in the Mu Us Desert in Northwest China, through the investigation and selection of mulberry trees in this area, the three excellent clones collected, MWS-1, MWS-2 and MWS-3, were compared with the mulberry variety SX-1 bred in Shaanxi Province for growth, quality and drought resistance etc research. The most suitable mulberry varieties for growing in the Mu Us desert area were screened out. A comparative analysis of the leaves of four mulberry clones was made using the membership function. The leaf quality of the four mulberry clones, according to the average membership function, it can be sorted as MWS-1>SX-1>MWS-2>MWS-3. Through a deeper and more systematic understanding of the biological characteristics of the four clones of mulberry, it provides a strong theoretical support for the production, popularization and application of mulberry in the Mu Us Desert in the future.*

Keywords: *mulberry; leaf characteristics; cultivar selection; leaf quality; Mu Us Desert*

1. Introduction

Morus (Morus spp.), a genus of Moraceae, has been cultivated for thousands of years,Mulberry can not only be used as a greening and garden tree species, but it is also a precious ornamental tree species and an important economic tree species[1]. As a small berry species, mulberries not only have mulberries that can be eaten,its leaves can also provide raw materials for feed and sericulture, and its economic value is the first of all types of shrubs[2-4]. At the same time, as an excellent native tree species, mulberry not only has a wide distribution, strong adaptability, and a high survival rate of afforestation, and it has a large canopy, which can be used for both ecological afforestation and landscaping. The nutritional value of mulberry leaves is about 40% to 50% higher than that of tropical leguminous forages, it is about 80% to 100% higher than that of grasses[5]. Mulberry leaves are rich in protein, vitamins, amino acids and trace elements, as well as a variety of nutrients and bioactive components such as polysaccharides, flavonoids, alkaloids and polyphenols[6-8], make the leaves of mulberry trees have higher economic value[9], many natural active substances in mulberry leaves, as feed, it has a certain immune health care effect on livestock and poultry, and can effectively prevent the occurrence of avian influenza, improving the disease resistance of livestock and poultry is conducive to maintaining healthy and rapid growth of livestock and poultry[10-14], it is precisely because of this that in recent years, industries such as "mulberry as feed" and "cultivating mulberry for raising livestock" have received extensive attention and application, at the same time, due to the excellent flavor index in mulberry leaves, the feed made from mulberry leaves can effectively improve the flavor quality of livestock and poultry products.

The Mu Us Desert is located in the southeastern depression of Ordos, including the south of Ordos City in Inner Mongolia Autonomous Region, the north of Yulin City in Shaanxi Province, and the northeast of Yanchi County in Ningxia Hui Autonomous Region. Geographically, the Mu Us Desert belongs to the transition area from the Ordos Plateau to the Loess Plateau, the central and western areas are covered on dry and denuded highlands and the beams that go deep into the depressions, and some places in the south are covered on loess hills. The main part of the desert is 1200-1600m above sea level and slopes from northwest to southeast (Figure 1,2); among them, the highest beam land in the northwest is about 1600m, and the beam land deep into the depression is mostly 1300-1500m, the southeastern river valley area can be as low as 1000m. The mulberry varieties studied in this paper developed in the Mu Us

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desert area.

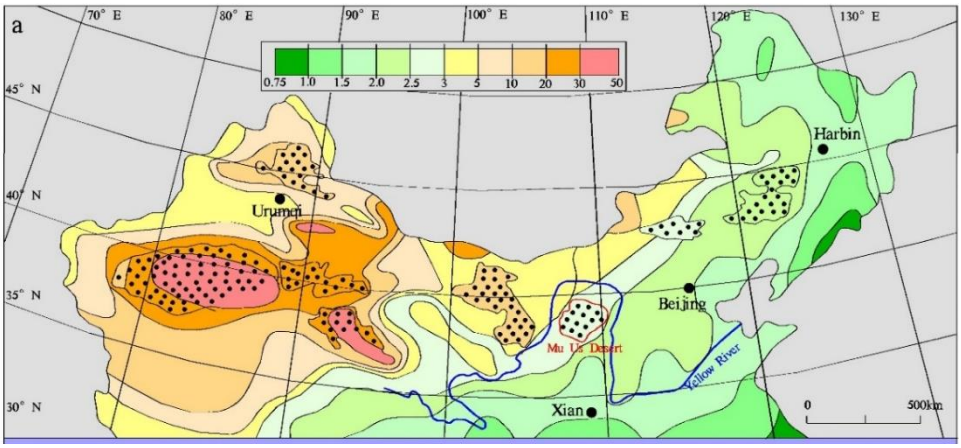

Figure 1: Geographical location of the Mu Us Desert

1.1 Materials and methods

1.1.1 Test material

In July 2020, for indicators such as mulberry leaf size, leaf quality and fruit yield, from the natural distribution of mulberry populations in the Mu Us Desert, three mulberry varieties were screened out in Yulin City, Shaanxi Province. MWS-1, MWS-2 and MWS-3, the main cultivar SX--1 in northwest China, were used as test materials. In the spring of 2021, the collected mulberry resources will be grafted and propagated. After the grafts are healed, field demonstration was carried out at the breeding base in June of the same year, and the planting density was 2 ×3 m, each clone was planted with 24 plants in the plot, with a total of four plots (Figure 3).

1.1.2 Determination method of mulberry leaf quality

Crude protein content: refer to the Kjeldahl method in GB 5009.5-2010 "Determination of Protein in Food"; Soluble sugar content: determined by anthrone colorimetric method; Mineral element content: The content of Ca and K was determined by dry digestion with flame atomic spectrophotometer[15-18]; The content of total flavonoids was determined by Al(NO3) colorimetric method[19-22] with rutin as the standard.

Figure 2: Natural Landscape in Mu Us Desert

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1.1.3 Data Analysis

The nutritional quality evaluation of mulberry leaves and fruits adopts the membership function value method in fuzzy mathematics[23]. The membership function value calculation formula is:

$$X(\mu)=(X-Xmin)/(Xmax-Xmin) \quad (1)$$

In the formula, X is the measured value of the index, and Xmax and Xmin are the maximum and minimum values of a certain index of all the tested materials, respectively. If it is negative correlation (bad indicator), use the inverse membership function to convert, and the calculation formula is:

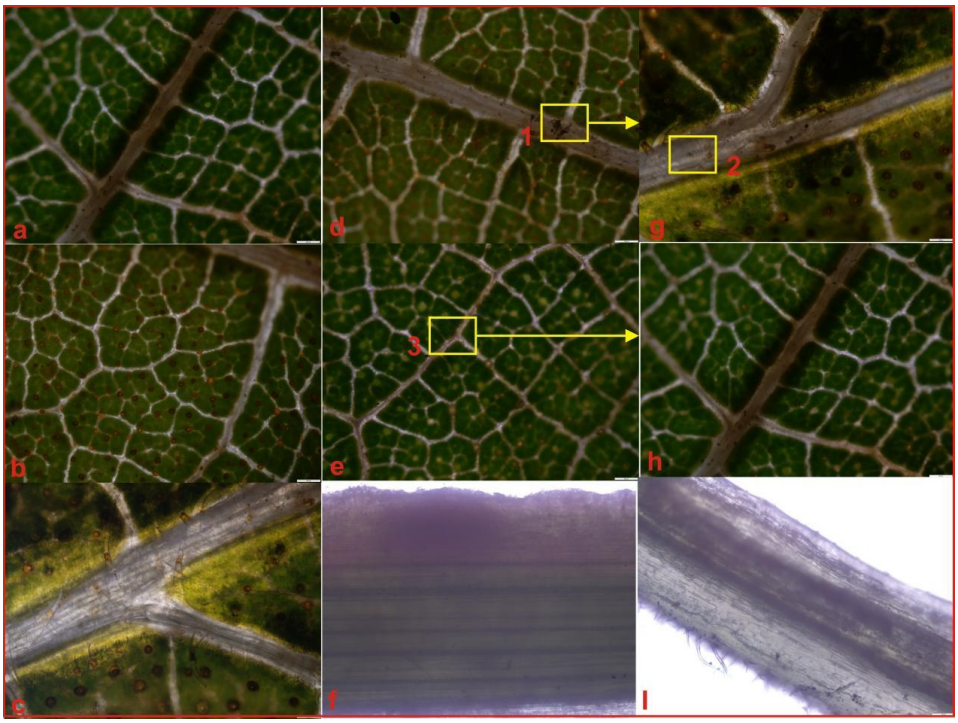
$$X(\mu A)=1-(X-Xmin)/(Xmax-Xmin)) \quad (2)$$

Finally, the average membership function value is calculated. The larger the average membership function value, the better the nutritional quality of the variety[22].

Table 1: Comparison of eaf quality of different clones of Morus spp.

clone	leaf area(cm^2)	Soluble suga(%)	Crude protei(%)	Flavonoids(mg/g)
LS	96.18±19.63bB	13.05±0.54aA	25.41±0.42bcAB	4.70±0.04dD
HLX	130.85±3.83aA	10.41±0.02bA	30.06±1.43aA	17.67±0.05aA
AEX	90.40±7.11bB	9.66±1.31 bA	28.49±2.10 abAB	7.82±0.02Cc
JA	96.63±7.18bB	10.61±2.36abA	24.47±2.17cB	8.10±0.01bB

The larger the average membership function value, the better the nutritional quality of the variety[23].



a-b Mulberry trees in study area
c Partially enlarged photo of mulberry leaves from Figure 1a
d-e Mulberry trees in study area
f Partially enlarged photo of the stalk
g Partially enlarged photo of mulberry leaves from Figure 1a
h-i Mulberry trees in study area

Figure 3: Microscopic characteristics of mulberry leaves in the study area

2. Results and analysis

2.1 Differences in leaf quality of different clones of mulberry

It can be seen from Table 1 that the leaf area of MWS-1 is 129.85 cm2, very significantly higher than the other three clones (P<0.01); The soluble sugar content of MWS-2 was 9.66%, which was significantly

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lower than that of the other three clones (P<0.05); The crude protein content of MWS-1 was 30.06%, followed by MWS-2 with a content of 28.49%, which was significantly higher than the other two clones (P<0.05); The flavonoid content of the four clones was significantly different (P<0.01), among which the flavonoid content of MWS-1 was 17.67 mg g-1, very significantly higher than the other three clones, followed by MWS-3, MWS-2, SX-1, 8.10 mg g-1, 7.82 mg g-1 and 4.70 mg g-1, respectively.

Table 2: The nutriants quality sequence of different clones of Morus spp. leaves

clone	membership function value				mean membership function value	Nutrient quality ranking
	leaf area	Soluble suga	Crude protei	Flavonoids		
LS	0.14	1.00	0.17	0.00	0.33	2
HLX	1.00	0.22	1.00	1.00	0.81	1
AEX	0.00	0.00	0.72	0.24	0.24	3
JA	0.15	0.28	0.00	0.26	0.17	4

2.2 Differences in quality characteristics of mulberry leaves of different clones

In this experiment, the quality of mulberry leaves is used as a comprehensive index, and the relative merits can be expressed by the average membership function value. According to formula (2), the average membership function value is calculated, and the quality is sorted (Table 2). From the calculation results of membership function values, it can be seen that the order of quality of mulberry leaves of the four clones is MWS-1>SX-1>MWS-2>MWS-3, at the same time, the degree of difference between them can also be seen. The average membership function value of MWS-1 is 0.81, the MWS-3 was only 0.17, indicating that the quality of mulberry leaves of different clones was significantly different.

Table 3: Comparison of fruit quality of different clones of Morus spp.

clone	Fresh fruit weight(g)	Soluble suga(%)	Soluble solids(%)	Ash(%)	flavonoids(mg /g)	anthocyanin(nmol/g)	crude protein(%)
LS	1.20±0.18cC	49.45±2.96bAB	13.50±0.86bB	5.16±0.04cC	4.25±0.06dD	5.47±0.49cC	9.97±0.19bB
HLX	2.31±0.37aA	41.12±2.61bcBC	18.75±0.47aA	5.35±0.03bB	8.17±0.05bB	12.54±0.19bB	12.11±0.85abAB
AEX	2.47±0.52aA	32.26±3.75cC	13.25±0.29bB	5.55±0.06Aa	12.50±0.02Aa	17.43±0.83Aa	14.37±1.14aA
JA	1.65±0.24bB	59.46±9.12aA	19.50±0.62aA	4.70±0.01dD	7.77±0.04cC	0.48±0.05dD	10.70±2.12bB

2.3 Differences in mulberry quality of different clones

It can be seen from Table 3 that there are significant differences in the mulberry quality of the four different clones, the fresh fruit weight of MWS-2 was the largest at 2.47 g, followed by MWS-1, the fresh weight of fruit was 2.31 g, which was significantly higher than that of the other two clones (P<0.01); The soluble sugar content of MWS-3 was 59.46%, which was significantly higher than that of the other three clones (P<0.05), followed by SX-1 and MWS-1, while MWS-2 has the lowest soluble sugar content of only 32.26%, and significantly lower than the other three clones (P<0.05); MWS-3 and MWS-1 had the highest content of soluble solids, 19.50% and 18.75%, respectively, which were significantly higher than SX-1 and MWS-2; The ash content and anthocyanin content of the four clones were significantly different (P<0.01),from high to low, they are MWS-2, MWS-1, SX-1, MWS-3; the flavonoid content of MWS-2 is 12.50 mg/g, the second is MWS-1, which is 8.17 mg/g, and the flavonoid content of MWS-3 is slightly less, which is 7.77 mg/g, the flavonoid content of SX-1 was the least, which was 4.25 mg/g, and there were extremely significant differences among the four clones (P<0.01); The crude protein content of MWS-2 was 14.37%, the highest among the four clones, secondly, the crude protein content of MWS-1 was 12.11%, which was significantly higher than that of SX-1 and MWS-3 (P<0.05).

Table 4: The nutrients quality sequence of different clones of Morus spp. Fruit

clone	membership function value							mean membership function value	Nutrient quality ranking
	Fresh fruit weight	Soluble suga	Soluble solids	Ash	flavonoids	anthocyanin	crude protein		
LS	0	0.63	0.04	0.54	0	0.29	0	0.22	4
HLX	0.87	0.33	0.88	0.76	0.48	0.71	0.49	0.65	2
AEX	1	0	0	1	1	1	1	0.71	1
JA	0.35	1	1	0	0.43	0	0.17	0.42	3

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2.4 Differences in mulberry fruit quality characteristics of different clones

In this experiment, the fresh weight, soluble sugar, soluble solids, ash, flavonoids, anthocyanins and crude protein contents of the fruits of the four clones were used as excellent indicators for mulberries, calculate the average membership function value and rank the quality. The results are shown in Table 4. The larger the average membership function value of the good quality index, the better the quality of the variety. The nutritional qualities of the four clones were ranked as MWS-2>MWS-1>MWS-4>SX-1, and the fruit fresh weight, ash, flavonoids, anthocyanins and crude protein contents of MWS-2 were all four. The largest of the clones, its average membership function value is 0.71; MWS-3 had the highest content of soluble sugars and soluble solids, but its membership functions of ash, ash and anthocyanin were 0, resulting in an average membership function value of 0.42; Although MWS-1 is not the highest content in each nutrient component, its average membership function value is 0.65, ranking second; However, the membership function values of SX-1's fruit fresh weight, flavonoids and crude protein content were all 0, resulting in its average membership function value of 0.22.

2.5 Differences in mineral elements of different clones of mulberry

From Table 5, it can be seen that the mineral content in the leaves and fruits of the four clones of mulberry is different. Among them, in mulberry leaves, the calcium content of MWS-2 and MWS-2 were 6.80% and 6.96%, respectively, which were significantly higher than the other two clones ($P<0.01$); The potassium content in SX-1 leaves was 1.89%, followed by MWS-1 leaves was 1.74%, both were extremely significantly higher than MWS-2 (1.51%) and MWS-3 (1.56%) ($P<0.01$). The content of SX-1 calcium in mulberries is 1.26%, was the highest MWS-1 of the four clones at 1.09%, ranking second, followed by MWS-2 with 0.98%, MWS-3 had the least calcium content with 0.79%, there were extremely significant differences among the four clones ($P<0.01$); The potassium content in the fruit is the highest in MWS-2 at 1.73%, and the lowest in MWS-3 at only 1.28%, and extremely significantly lower than the other three clones ($P<0.01$).

Table 5: Comparison of mineral elements in leaves and fruits of different clones of Morus spp.

clone	blade		fruit	
	calcium(%)	potassium(%)	calcium (%)	potassium (%)
LS	4.92±0.05cC	1.89±0.04aA	1.26±0.00 aA	1.48±0.00 bB
HLX	6.80±0.13aA	1.74±0.04bB	1.09±0.03 bB	1.50±0.03 bB
AEX	6.96±0.02aA	1.51±0.05cC	0.98±0.02 cC	1.73±0.01 aA
JA	6.31±0.16bB	1.56±0.05cC	0.79±0.01dD	1.28±0.02 cC

3. Conclusion

Among the four clones of mulberry, MWS-1 leaves had the highest nutritional quality, among them, its leaf area, crude protein content and flavonoid content are the largest among the four clones, and its fruit nutritional quality also ranked second among the four clones; The nutritional quality of the leaves of SX-1 ranked second, and its soluble sugar content was the highest among the four clones, however its flavonoid content is the lowest, resulting in poor nutritional quality of its fruit, the fresh fruit weight, flavonoids and crude protein contents were the least among the four clones; The nutritional quality of MWS-2 leaves ranks third, but its fruit has the highest nutritional quality, its leaf area and leaf soluble sugar as well as the soluble sugar and soluble protein content in fruit were the least among the four clones, however the content of ash, flavonoids, anthocyanins and crude protein in its fruit is the highest. The nutritional quality of leaves and fruits of MWS-3 ranked fourth and third, respectively, this is because the crude protein content in the leaves and the ash and anthocyanin content in the fruit are the lowest, but the content of soluble sugar and soluble protein in its fruit is the highest among the four clones.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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