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A PRELIMINARY STUDY OF THREE CHINESE WOOD SPECIES FOR TRADITIONAL CHINESE FURNITURE

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Abstract: *Traditional Chinese furniture is a valuable part of world cultural heritage. Its long history can be divided into four periods: "the youth period", "the growth period", "the development period" and "the maturity period", with specific characteristics in terms of style, decoration and materials. From a great variety of wood species used for traditional Chinese furniture, Chinese walnut (Juglans mandshurica Maxim), Manchurian ash (Fraxinus mandshurica) and Paulownia (Paulownia elongata) were selected for this preliminary study. The paper presents a brief macroscopic and microscopic characterization of these species, alongside colour measurements in the CIELab system. These results will be used as starting data in a further study on the finishing and ageing of these wooden supports, for scientific conservation purposes*

Key words: *traditional Chinese furniture, wood species, macroscopic features, microscopy, colour measurements.*

1. Introduction

China is one of the oldest countries in the world, having more than 6000 years of history. The traditional Chinese furniture evolved as an important part of the Chinese culture and civilization. It varied from one historical period to another, expressing specific patterns of style and skilfulness characteristic to each period [10]. It can be divided into four historical periods as follows: *the youth period, the growth period, the development period* and *the maturity period*.

Along *the youth period* (possible BC 5000 – BC 770) furniture was simple; we can actually speak about a mat-level furniture, as a characteristic for this period, but the lacquer finishing technique was already known. In *the growth period* (BC 770 – AD 220) furniture was also short, bronze furniture and folding furniture appeared. In *the development period* (AD 220 – AD 979) the high furniture appeared, Buddhism began to have a big influence on the decoration of furniture. Therefore, different from the pure black and red finishing, a new type of decoration was introduced, illustrating beast gods and clouds images on a dark green background. In *the maturity period* (AD.960 – AD 1911), up to the Song Dynasty, tall furniture formed a relatively complete system, comprising specific types of beds (ta, luo han chuang, da wei chuang), depositing boxes cabinets, chairs, garment, tables, chests, cupboards and screens. The period of Ming and Qing

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dynasties is considered the peak of development of the traditional Chinese furniture [11]. Two examples of elegant furniture from this period can be seen in Fig.1 and Fig.2 [1].

Fig.1. *Daybed made of Chinese walnut (Juglans mandshurica Maxim) in 18th century*

Fig. 2. *A screen made of Huang Hua Li (Dalbergia odorifera T.Chen)*

Different wood species, both Chinese (e.g. Chinese walnut, Chinese walnut, Manchurian ash, Camphor Wood) and precious imported ones (e.g. Sandalwood, Yellow rose wood, rose wood), were used for furniture in these historic periods [8].

Most of these species have specific Chinese names and are less known in Europe. Traditional Chinese furniture is widely collected in several major museums in China and abroad, also by private collectors and connoisseurs [10]. Furniture conservation is of great importance in the general context of cultural heritage conservation. The conservation of historic furniture has lately become more and more involved with a scientific interdisciplinary approach. In this sense, the study and identification of materials from wood species to adhesives and finishing materials is a necessary step [4], [5], [9].

2. Objectives

The present paper is a first step in a PhD research project focusing on a comparative study of ageing phenomena of wooden support and transparent traditional finishes for European and Chinese furniture.

The current objectives were:

- Selection of wood species for experiments.
- Synthesis of literature data on the physical mechanical properties of the selected species.
- Preliminary macroscopic and microscopic investigation.
- Colour measurements.

3. Material and methods

3.1. Wooden materials

The selection of species was based on their importance (extent of utilization) in traditional Chinese furniture. Three wood species were selected: Chinese walnut (*Juglans mandshurica Maxim*), Manchurian ash (*Fraxinus mandshurica*) and paulownia (*Paulownia elongata*). These are presented in Table 1, alongside their experimental codes.

The wooden material employed for these experiments originated from different Chinese regions. Chinese walnut and Manchurian ash originated from Dandong, Liaoning province and paulownia originated from the outskirts of Beijing. The study was divided in three distinct experiments: macroscopic observation, microscopic investigation and colour measurements. The codes, size (Longitudinal × Radial × Tangential) and the moisture content of the wood samples for experiments are presented in Table 2.

The three selected wood species for the experiments Table 1

Chinese name	English name	Latin name	Code	Remarks [2,6]
核桃楸 (he tao qiu)	Chinese walnut	*Juglans mandshurica* Maxim	H	One of the three most precious species in east-northern China
水曲柳 (shui qu liu)	Manchurian ash	*Fraxinus mandshurica*	S	One of the three most precious species in east-northern China
泡桐 (pao tong)	Paulownia	*Paulownia elongata*	T	One of the nine species of fast growing timber trees

Test samples used in the experiments Table 2

Experiment	Species	Code	Size(L*R*T)	Moisture content (%)	Pieces
Macroscopic	Chinese walnut	H_{ma}	30mm*70mm*70mm	10-12	3
	Manchurian ash	S_{ma}	30mm*70mm*70mm	10-12	3
	Paulownia	T_{ma}	30mm*70mm*70mm	10-12	3
Microscopy	Chinese walnut	H_{mi}	30mm*10mm*10mm	10-12	2
	Manchurian ash	S_{mi}	30mm*10mm*10mm	10-12	2
	Paulownia	T_{mi}	30mm*10mm*10mm	10-12	2
Colour measurement	Chinese walnut	H_c	120mm*70mm*7mm	10-12	6
	Manchurian ash	S_c	120mm*70mm*7mm	10-12	6
	Paulownia	T_c	120mm*70mm*7mm	10-12	6

3.2. Methods and equipment

Macroscopic: The samples with size of 30mm*70mm*70mm were sanded with abrasive paper H80 and further cleaned of dust. These were examined with naked eye and under magnifying glass to observe characteristic features. For documentation purposes the samples were scanned on the three characteristic sections (transversal, Radial, Tangential) by a HP LaserJet Pro CM1415 Colour Multifunction Printer. A 1 cm long measuring bar was marked on each face.

Microscopy: The samples with size of 30mm*10mm*10mm were plasticised by boiling in water in flasks with refluxing condenser for about 24 hours. The prisms were trimmed to expose the transverse, radial and tangential surfaces. Sections were cut from each surface with a sledge microtome at 25 micron thickness. Ethanol solution was used to prevent surface tension attaching the sections to the knife. To enhance the contrast, the sections were coloured with 1% safranine solution by immersion for 90 seconds and then washed thoroughly in baths of distilled water. After this, the sections were put on glass microscope lamellas and covered with thin covering glasses. The microscopic slides were examined under an optical stereomicroscope BIOSTAR OPTECH B5 fitted with an image capture system. From each slide there were taken several images on each section at magnifications of 40x and 90x. The main features considered were: the type and arrangement of pores, the presence of some deposits into vessel elements, fibres areas, rays and other particularities.

Colour measurements: The samples with size of 120mm*70mm*7mm were sanded with abrasive paper H80 and further cleaned of dust. A paper template, with the dimensions of the test samples, with 5 holes (□ = 4mm) was made to identically mark the samples for colour measurements. Four holes were situated at 1.5 cm of margins and the fifth one in the centre of the sample. An AvaSpec-USB2 spectrometer equipped with a reflection probe FCR 7UV (with 6 illumination fibres and 1 read fibre) and the dedicated AVASOFT for versions 7.7 were employed. The colour parameters under D65 illuminate, at 90 degrees illumination in the CIELab system (L, a, b) were recorded for each sample in the 5 measuring points.

4. Results and discussion

4.1. Summary of literature data on some physical and mechanical properties

A summary of literature data referring to some of the main physical-mechanical wood properties and utilization of the three wood species is presented in Table 3.

Table 3

The physical-mechanical wood properties and utilization of the three wood species

Species	**Physical-mechanical** [2, 3, 6, 7]	**Utilization** [12, 13]
Chinese walnut (*Juglans mandshurica* Maxim)	Density:525-624kg/m^3 MOR 83.9 MPa Compressive strength: 51.2MPa	Furniture and interior joinery constructions, music instruments, sport items, etc
Manchurian ash (*Fraxinus mandshurica*)	Density:564-658kg/m^3 MOR 183-257 MPa Compressive strength: 74.6 MPa	Furniture, flooring, doors, architectural millwork and molding, kitchen cabinets etc.
Paulownia (*Paulownia elongata*)	Density:209-283kg/m^3 MOR 42.6 MPa Compressive strength: 15.9-19.7 MPa	Furniture, house structure, paper pulp, MDF etc.

4.2. Macroscopic features

The macroscopic views of the transversal, tangential and radial sections for these species are presented in Figure 3.

The images for Chinese walnut (*Juglans mandshurica Maxim*) show clearly visible waved annual rings and diffuse pores, visible with the naked eye on all the three characteristic sections. Rays are not visible with the naked eye on the cross section, but in radial section they occur as small, shiny mirrors.

The images for Manchurian ash (*Fraxinus mandshurica*) show also clearly visible annual rings (fig.3b). Pores are visible with the naked eye and grouped in typical ring porous structure. Rays are not visible with the naked eye on the cross section, but in radial section they occur as shiny areas.

The images for Paulownia (*Paulownia elongata*) show clearly visible annual rings. Pores are visible with the naked eye, distributed corresponding to semi ring to ring porous wood species. The rays are not visible with naked eyes but appear under a magnifying glass.

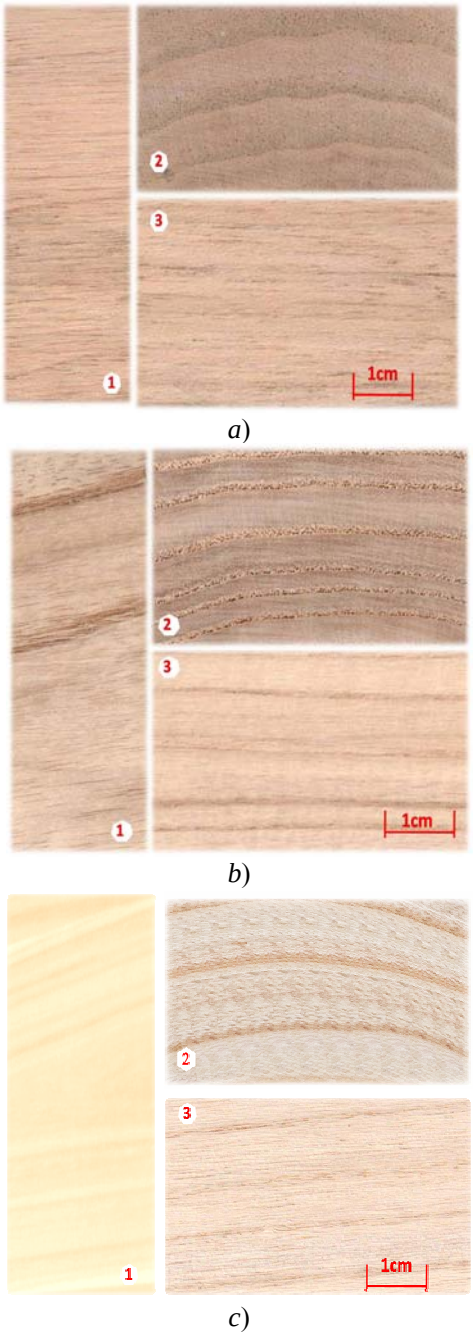


Fig.3. *Macroscopic views of the three species: a) Chinese walnut; b) Manchurian ash; c) Paulownias (1.Tangential section, 2.Transversal section, 3.radial section).*

4.3. Microscopic investigation

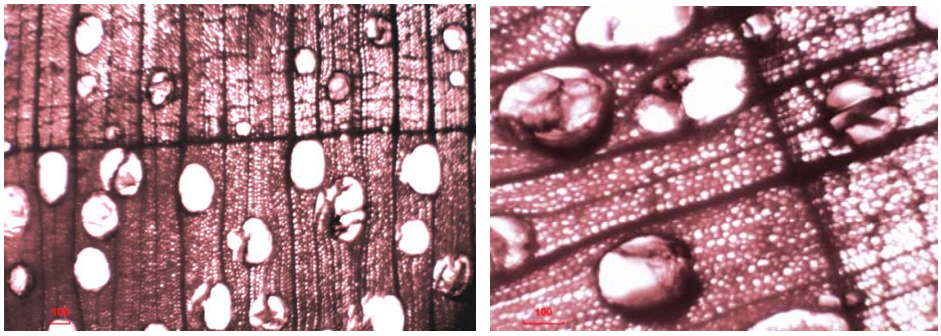
From the images produced at various magnifications, the larger magnification 90x contains more detailed information, but the area included has less anatomical details, while the smaller magnification 40x gives more information about the pores distribution within and between annual rings, as well as distribution of parenchyma. Therefore, examination at both these magnifications is useful. From all the sections, the transverse one provides the most relevant information and that is why only the microscopic images of cross sections for the investigated species: Chinese walnut, Manchurian ash and paulownia are presented in this paper in figures 4, 5 and 6.

Chinese walnut: In figure 4 for Chinese walnut (*Juglans mandshurica* Maxim) big oval diffuse pores can be observed. The vessels from latewood are smaller than the ones from early wood. They are partially filled with deposits as can be seen in figure 4b. The rays can be distinguished as darker straight lines. The distance between two adjacent rays is almost the same with the diameter of vessels. Fibre areas appear compact and uniform.

Manchurian ash: In figure 5 there are presented the microscopic images for Manchurian ash (*Fraxinus mandshurica*). A structure characteristic for a ring porous wood species is evident at smaller magnification. The vessels from earlywood are big, elliptic in shape and single or in groups. They are disposed in multiple rows. The vessels from latewood are smaller and solitary or in pairs. Some darker areas around vessels from late wood indicate presence of parenchyma (figure 5a). The rays are both uniseriate and multiseriate,

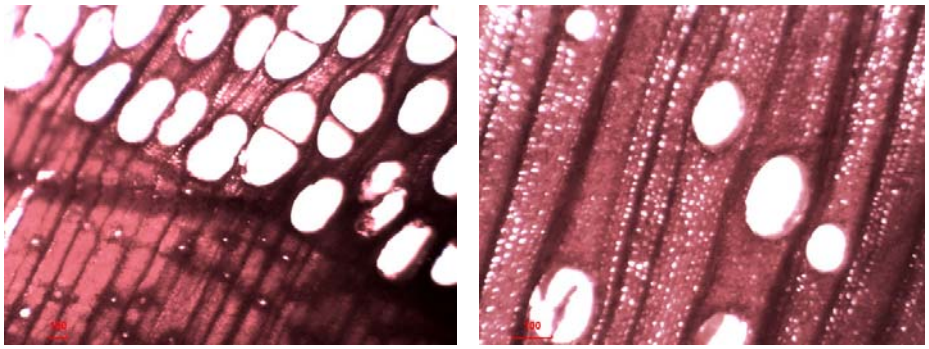
Paulownia: It is characterized as semi-ring or ring porous wood species according to images from figure 6. In cross section pores are round or elliptic. The difference in the vessel size between early and late

wood is obvious. The vessels are mostly solitary; sometimes in pairs. Bubble - shaped tyloses are present in the vessels; more in the vessels of early wood than in late wood. The diameter of vessels in early wood measured 250-300µm as can be seen in figure 6b. The rays are both uniseriate and multiseriate, Wood parenchyma is present mostly around the vessels of late wood. Wood fibre cells seem to be even in size.



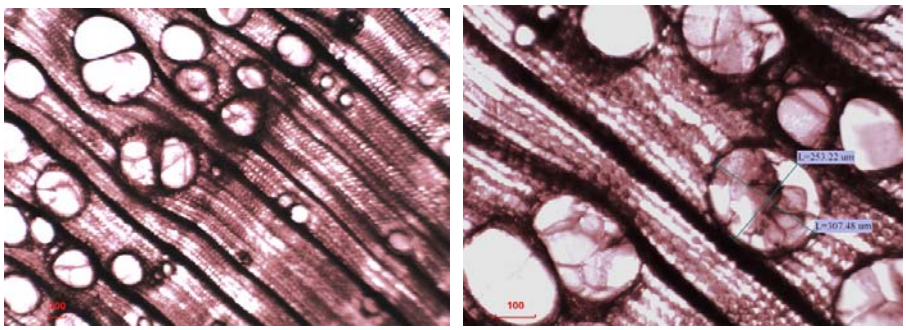
a) *b)*

Fig.4. *Micrographs of Chinese walnut on transversal section:*
a) 40x magnification. b) 90x magnification



a) *b*)

Fig.5. *Micrographs of Manchurian ash on transversal section:*
a) 40x magnification. b) 90x magnification



a) *b)*

Fig.6. *Micrographs of Paulownia on transversal section:*
a) 40x magnification. b) 90x magnification

4.4. Colour measurement

The result of colour measurement is presented in table 4. It has to be mentioned that these values are the average values resulting from 6 replicate samples and 5 measuring points were included for each sample. It is also obvious from the macroscopic images that the colour is not uniform, but notable differences are between latewood and earlywood, especially for walnut and ash. Therefore, the standard deviation and the minimum and the highest values for L, a, b parameters were also included in the table. According to the mean L values, Paulownia wood is the lightest in colour, while Chinese walnut wood is the darkest one.

Colour parameters of the three species wood Table 4

Species	**Colour parameters**		
	L **Mean value** **(STDEV)** **Min-Max**	**a** **Mean value** **(STDEV)** **Min-Max**	**b** **Mean value** **(STDEV)** **Min-Max**
Chinese walnut (*Juglans mandshurica* Maxim)	70.142 (5.118) 62.7-82.72	8.428(1.285) 5.81-10.61	25.964 (2.061) 22.18-30.46
Manchurian ash (*Fraxinus mandshurica*)	76.868 (2.990) 73.52-85.3	8.256 (0.981) 5.67-9.7	30.254 (1.797) 34.3-26.28
Paulownia (*Paulownia elongata*)	86.916 (2.169) 81.27-90.46	3.75 (1.301) 1.72-6.88	26.412 (4.781) 12.12-32.79

5. Conclusions

Traditional Chinese furniture is becoming more and more important for collectors, connoisseurs and historical research. Conservation and restoration of this cultural treasure imposes a scientific approach. Considered this way, some studies on wood species used for traditional Chinese furniture are very important and necessary.

The paper presents a brief macroscopic and microscopic characterization of three Chinese wood species important for historic furniture: Chinese walnut, Manchurian ash and paulownias. The colour measurements in the CIELab system showed the colour differences between the species and within the same wood species and test sample, due to their macroscopic and microscopic features. These colour measurement results will be used as reference data in a further study on the finishing and ageing of these wooden supports, for scientific conservation purposes.

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