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CHECKING THE ORIGINALITY OF TAR MUSICAL INSTRUMENT BY USING DENDROCHRONOLOGY

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ABSTRACT

Determining the originality of the art objects are always a big task for evaluators. Those objects which have woods in their structures have the chance of using tree-rings pattern as a sign of originality. *TAR* is one of the most popular Iranian musical instruments which can be considered as one of the national musical instruments of Iran. The construction of today's TARs started about the year 1890 in Isfahan. Some of the most famous producers of *TARs* were *YAHYA*, *ABBAS* and *JAFAR*. Due to the value of their products, a lot of collection owners claim that they have some of these famous *TARs*. Isfahan musical museum have two TARs which one of them is claimed to be made by *ABBAS* (TAR II) and another by *JAFAR* (TAR III). For investigating these claims, the mentioned TARs were compared chronologically with one original *ABBAS* sample (TAR I). For this purpose, a Canon EOS 6D camera, ImagJ software and TSAP-Win software has been used to take photographs, analyze photos, measure the annual rings distances and cross date of the TAR's woods. Results illustrated that annual rings in all directions in TAR II and TAR III are compatible with the original sample (TAR I). It seems that used woods for producing all three TARs have similar chronological characters and it can be approved that production period of TARs and original region of their woods are almost the same in the middle of 20th century.

KEYWORDS: TAR, Chronology, Wood, Annual Rings, Musical instrument, Iran, Isfahan, museum

1. INTRODUCTION

TAR, is one of the Iranian musical instruments, which is considered as the most complete and popular traditional musical instrument (Mashhon, 2010). This musical instrument is in the group of Iranian string musical instruments such as dotār, setār and etc., which are different in the shape of bowl and the number of their strings (Tar has 6 strings, dotār has 2 strings and setār has 4 strings). The current shape of TAR is formed in the nineteenth century. The body is a double-bowl shape carved from *mulberry* wood, with a thin membrane of stretched lamb-skin covering the top. The long flat fingerboard has twenty-five to twenty-eight adjustable gutfrets, and there are three double courses of strings. *Morus alba* L. is the main species for making traditional bowl shaped musical instruments (*TAR, SETAR and KAMAN*) in Iran (Pourtahmasi and Golpayegani 2009).

Different materials such as wood, bone and horn have been used for producing different parts of a *TAR*, such as bow and neck, surface of the neck, and saddle, respectively (Masoud, 2002). A *TAR* includes double bowls that are placed near each other with a ∞ shape. The smaller bowl act as a body of resonance in the instrument (Masoudiye, 2006). *TAR* contains six wires which are crossed from the saddle and connected to tuning keys. After the small bowl, is the place of neck; some frets exist in the length of neck, and in the ends of that is the location of tuning keys (Jenkins and Olsen, 1976).

To construct a *TAR*, berry trees which are grown in the dry regions preferred (Mashhon, 2010). In addition, the best time for cut off the related tree is in the falls because trees are asleep and then there is no flow of water and juice in them (Masoudiye, 2006). In order to construct a *TAR*, after selection an appropriate part of tree's trunk, producer will cut it in perpendicular direction of radius to make two similar separate parts (Mashhon, 2010). So, the process of making TAR bowls starts from the time when the trees are cut down and the woods are still wet and there is a short time between cutting down the trees and starting the production. For this reason choronology is a suitable metod to recognize the originality of TARS (Masoudiye, 2006). After carving each prepared part to the shape of half of big and small bowl, for assembling the *TAR*, two parts bind to each other in a way that annual rings match in both sides (Mashhon, 2010).

It is not clear from when the current name was considered for this valuable musical instrument (Shabani, 1973). However, it is proved that until the era of *Safavid* (1501 to 1736 AD) , we didn't have the name and shape of today's *TARs* (Khaleqi, 1956). Thus, it can be said today's form of TAR had been constructed in the 19th century. Nevertheless, it is undeniable that historical samples of this instrument are ornamentations in different museums. The peak of the art for producing TAR can be considered late in the *Qajar* and early *Pahlavi* periods (19th and 20th century) in Isfahan which some famous artists such as *Hovhannes Abkarian* (known as "*YAHYA*") and his disciples, whose names were *ABBAS SANAT* and *JAFAR SANAT* (two brothers) have built some of the best possible samples of TARs in the early 20th century and These are good patterns for current producers (Mashhon, 2010). Due to importance and worthiness of these primary samples, determining of the production time is so important for detecting historic data and originality of them. Moreover, due to a lot of fake samples that are related to the last of *Qajar*, detecting original samples from fake ones is so important for providing valuable data about time period of the production. Hence, with comparing and matching of unknown samples with original ones could investigate the originality of them.

It should be mentioned that there is another type of TAR which known as Azerbaijani TAR. While, Iranian TAR has a convex bowl and should be played in sitting position but the bowl in Azerbaijani TAR is flat so it should be played while the player is standing (Shabani, 1973).

In the early 15th century, the relationship between the tree rings and the rainfall during the growth period was carried out by Leonardo da Vinci (Stallings et al., 1937). What is certain, Douglas is the father of dendrochronology science that started his investigation at 1901 with studying of a tree growth curve from Flagstaff and comparing with regions in Prescott and Arizona (Cook and Kairiukstis, 1980, Douglass, 1914, Douglass, 1919, Douglass, 1921). After that, several researchers have been focused on this topic which some of the most important ones are monographic study of dendroclimatology (Schulman, 1958), developing qualitative analytical techniques and entrance of computer for analytical methods in dendroclimatology study (Schweingruber, 1988). In addition, Bruno Huber investigations was a turning gold point for study of trees chronology (Fritts, 1976).

Dendrochronology has established itself as a standard dating tool and has been applied in a wide variety of (pre-)historical studies (Schwartz, 2021). Archaeological wood, historical buildings, works of art (such as panel paintings and sculptures) have been successfully investigated. It is possible to determine the exact year in which the tree was felled but in cases in which the last ring is not available and no sapwood is preserved, it is only possible to provide a terminus post quem, i.e. the date after which a tree must have been felled or the 'earliest possible felling date (Haneca et al., 2009).

The use of dendrochronology in the field of musical instruments can be traced to the dating of the Messiah violin, which was constructed by the Italian luthier, Antonio Stradivari and labeled with the date of 1716 (Topham and McCormick, 2000). After that, similar studies were done with other scientists about different musical instruments such as string instruments (Grissino-Mayer, et al., 2004), violins (Grissino-Mayer, et al., 2005) and bowed instruments (Bernabei, et al., 2010; Bernabei and Bontadi, 2011).

Almost all the time, it's an important concern for the musicians and collectors to determine the originality of musical instruments. Since ABBAS and JAFAR TARs are really valuable, so annual rings can be used to investigate the originality of the TARs. In this study, two suspicions TAR samples were received from Isfahan Music Museum to check the originality of them. Since there isn't a valuable geographical chronological database in Iran so an original ABBAS TAR taken from Isfahan Music Museum used as a base for comparing and dating.

2. MATERIALS AND METHODS

Three different TARs were received from Isfahan Music Museum. Among these samples, one of them is directly purchased from *ABBAS* workshop and its originality is proved by the museum. However, Isfahan Music Museum provided two other samples from different sources and originality of them are not proved yet, but it is highly claimed that one of these samples is *ABBAS* artwork and another one is related to his brother, *JAFAR*. Main production characters of these samples are illustrated in Table.

Table 1. TAR samples characters

Characters/Samples	TAR I	TAR II	TAR III
Historic records	It is proved as ABBAS work.	It is claimed to be ABBAS work.	It is claimed to be JAFAR work.
Length of big bowl	170 mm	170 mm	170 mm
Length of small bowl	80 mm	80 mm	80 mm
Big bowl diameter	149 mm	149 mm	150 mm
Small bowl diameter	79 mm	79 mm	80 mm
Neck length	460 mm	460 mm	460 mm

Figure 1. Images of investigated samples a) TAR I, b) TAR II and c) TAR III.

Figure 2. photo by The Dino-Lite Premier AM3113T, texture of Morus alba

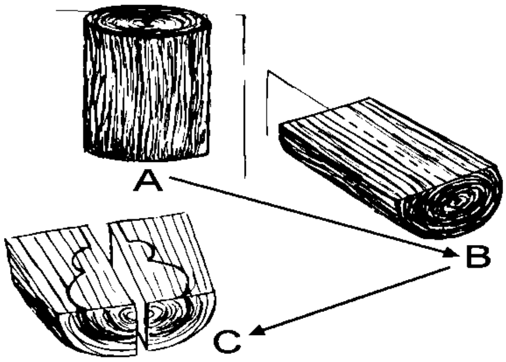


Figure 3. Pattern of cutting wood for producing a TAR

Besides chronology, there are several methods for recognizing the originality of a historical wood, such as near-infrared (NIR) (Sandak, et al., 2011) and NMR and IR characterization (Santoni, et al., 2015). Since these methods need sampling and were destructive, so photography used as a nondestructive and suitable method of dendrochronology.

There are different Dendrochronology methods for measuring tree-rings such as: traditional dendrochronograph (which is consist of a stereomicroscope associated with a micrometric movement mechanism, Portable dendrochronograph (a controlled movement system connected with a digital camera) and Photographic sampling.

Although there are some disadvantages of photographic sampling, mainly related to calibration of the measurements, parallax errors and image distortions induced by lenses (Bernabel and Cufar, 2018), due to the fact that traditional and portable dendrochronograph weren't available and the aim of this study has been determining the originality of the TARs not specifically dating them, so photographic sampling method was chosen. (Cufara, et al, 2016).

TAR's bowl wood (small and big bowl) was used for measuring annual-rings width and providing required graphs to identify the authenticity of samples. Due to trustworthy of measured values, three different parts of the bows were considered for the study such as Upside, Downside, and Backside which are named as "U", "D", and "B", respectively (Fig. 3). As Fig. 1, in each mentioned regions, two sides were considered separately that each one is related to a side of primary tree's trunk, and adaptability of values was investigated.

Unfortunately, there is a lack of chronological database for dating and provenance in Iran but due to the fact that TAR makers which are being studied in this article, worked in the middle of 20^{th} century (in this article in Isfahan), one original ABBAS sample (TAR I) is used to identify the originality of other TARs.

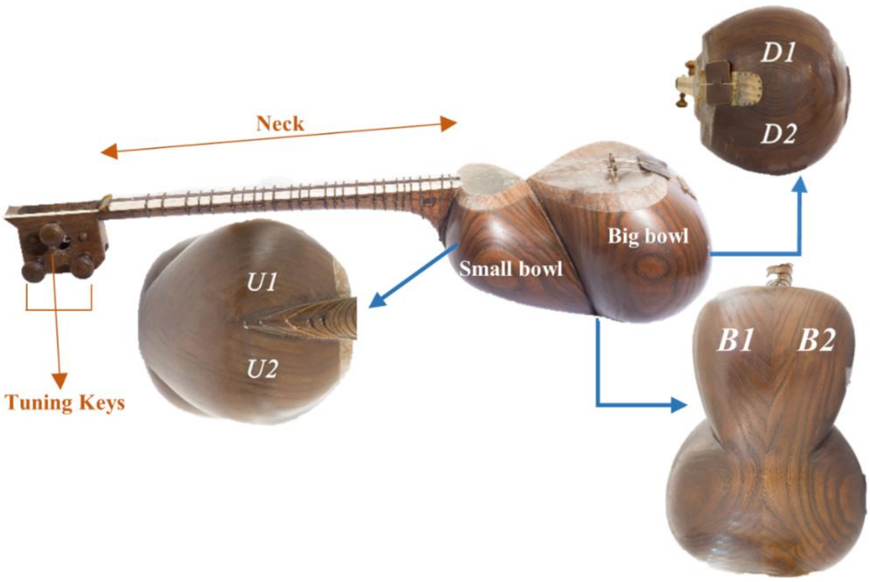


Figure 4. Different parts of the bowl which are considered for recording rings.

Traditionally, the process of construction of the soundboard of a TAR starts with a half sawn piece of wood. In the next step, each half will get the form of a semi-bowl and join to each other (fig.3). It is generally advisable to perform at least two tree-ring width measurements for each portion of the bowl, possibly at different locations. After the measurements have been taken, the tree-ring series can be immediately compared (Bernabel, Cufar.,2018). In this study different parts of the bowl were considered for recording rings (fig4).

The following process is considered for investigation and evaluation of ring width and comparison different TARs:

a) Measurement in each TAR

- Measuring ring width in two sides of each regions (B1, B2, U1, U2, D1, and D2);
- Checking the validity of values in each side with comprising them (B1 with B2, U1 with U2, and D1with D2);
- Preparing averages for each region (ave. B, ave. U, and ave. D);
- Checking validity of values in each region with comprising them (ave. B with ave. U and ave. D, and ave. U with ave. D);
- Preparing averages for each TAR (ave. TAR I, ave. TAR II, and ave. TAR III);

b) Comparison of different TARs

Canon EOS 6D camera was used for photography of samples. For decreasing perspective errors, normal lens was used. In addition, for omission of hand shaking and increasing pictures resolution, camera tripod was used for all photos.The measurement accuracy depends on the quality of a digital image as well as on the print quality (Nasswettrovand and Smira, 2017).

ImagJ software was used for analyzing photos and measuring the annual rings distances. For standardization of pictures, during photography one Dino-Lite calibration sample in micron scale was used.

For cross matching the ring width data has been exported to *TSAP-Win* software. visual crossdating, annual increments are measured using a sliding measuring stage and statistical accuracy of crossdating is checked using software programs such as, *TSAP-Win*, or other user-created packages (Bunn, 2008).

In this software, visual matching and statistical analysis have been done using *Gleichläufigkeit* (GLK), the GLK significance (GSL), the Cross correlation ***=95% , **=99% ,***=99.9%** (CC), the T-value Baillie-Pilcher (TV BP) and Cross Date Index (CDI) values (Rinn 2003).

used at two states of the analysis: a) For verification of series and the elimination of possible errors, b) to find the correct dated position in time.

After measurement, cross-dating is an important step before analysis of time series. Elimination of measurement errors, e.g. removal of so called "false rings" and insertion of "missing rings" are a must before you start any type of time series analysis CROSS-DATING PARAMETERS (Rinn, 2003).

In dendrochronology two main concepts are used to express the quality of accordance between time series: *Gleichlaeufigkeit* and/or t-values. While the t-statistic is a widely known test for correlation significance, *Gleichlaeufigkeit* was developed as a special tool for cross-dating of tree-ring series (Eckstein and Bauch1969).

These concepts are characterized by a different sensitivity to tree-ring patterns. While *Gleichlaeufigkeit* represents the overall accordance of two series, *t-values* are sensitive to extreme values, such as event years. A combination of both is realized in the Cross-Date Index (CDI). Since the CDI is a very powerful parameter in cross-dating, the possible matches are ordered by descending CDI in the output Cross-date mode:

Find match: Finds the best matches according to the cross-date index, which is calculated from t-value and "*Gleichlaufigkeit*" (see statistical parameters).

We found that the cross-date index (CDI) gives a fairly good indication for the correct match, since it combines t-value and *Gleichlaeufigkeit* (Rinn, 2003).

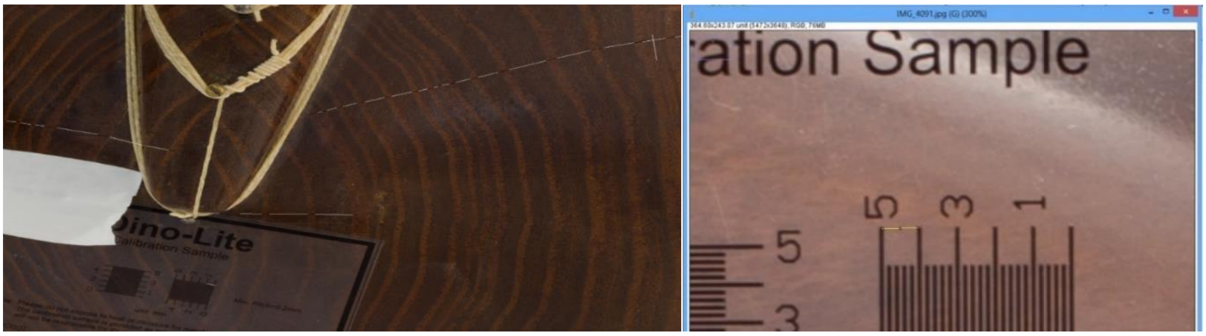


Figure 5. The process of taking photos, analyzing and measuring (using calibration sample)

Table 2. TAR Camera setting

Dmension	H.V Resolution	Bit dep	Resolution unit	Color representation	Iso speed	Focal length	Max aperture	Flash mode	Camera model
5472x3648 pix	240 dpi	24	2	sRGB	100	50 mm	1.7	No	Canon EOS 6D

3. RESULT AND DISCUSSION

In this study, annual-rings width was measured and comprised with each other. For each sample, separate graphs were prepared from different regions of the bow and average values are considered for final comparisons. the first step, the measured data sets in the form of dendrochronological curves were compared with each other using the *TSAPWin* software (Nasswettrovand and Smira, 2017). Table 3 shows related results of calculations and adaptability of values in each TAR.

Table 3. Checking similarities of annual-rings width values in each TAR.

Name	Side	Side	GLK	GSL	%CC	TVBP	CDI
TAR I	B1	B2	83	***	67	5.1	44
	D1	D2	82	***	89	12.2	99
	U1	U2	89	***	93	11.4	110
	ave. B	ave. D	77	***	86	10	82
	ave. B	ave. U	83	***	77	8.6	67
	ave. D	ave. U	83	***	94	9.8	106
TAR II	B1	B2	88	***	78	6.3	53
	D1	D2	75	***	88	9.5	80
	U1	U2	89	***	93	10.8	101
	ave. B	ave. D	62		66	5.7	38
	ave. B	ave. U	81	***	71	7.1	59
	ave. D	ave. U	74	**	91	9.7	72
TAR III	B1	B2	89	***	69	4.4	55
	D1	D2	92	***	60	6.6	71
	U1	U2	100	***	80	7.7	95
	ave. B	ave. D	100	***	79	5.4	74
	ave. B	ave. U	100	***	87	3.6	53
	ave. D	ave. U	100	***	74	8	77

As Table 3 illustrates, the calculated values of GLK, GSL, CC, TV BP and CDI for comparison of B1 with B2, U1 with U2, and D1 with D2, in most cases are good for checking the similarities of two sides of bowl's wood which makes values acceptable for calculation of averages rings-width in each TAR which means each half of every TAR body has been built by a similar tree wood.

The next step was checking the similarities of averages in each region of TARs. For this reason, related values of ave. B, ave. U and ave. D are presented in Table. 3 for each *TAR*.

According to Fig. 2 and related calculations results in Table. 3, in *TAR I* complete similarities exist; while some deviations are significant in *TAR II*; in this *TAR*, values for averages in B and U regions are showing very good similarities while the region D with two others is lower and it is more lower in comparison of B and D which GLK is 62 and no significant GLK provided This is probably due to the fact that various cut for made the TAR has been used. However, GLK=74 and two star GSL in comparison of U with D was a positive sign. so take averages rings-width between U and D Moreover, according to Fig.2 and Table. 3, high similarity of ring width has been found in three regions of D, U and B in TAR III, represents the very good match between rings of the whole regions.

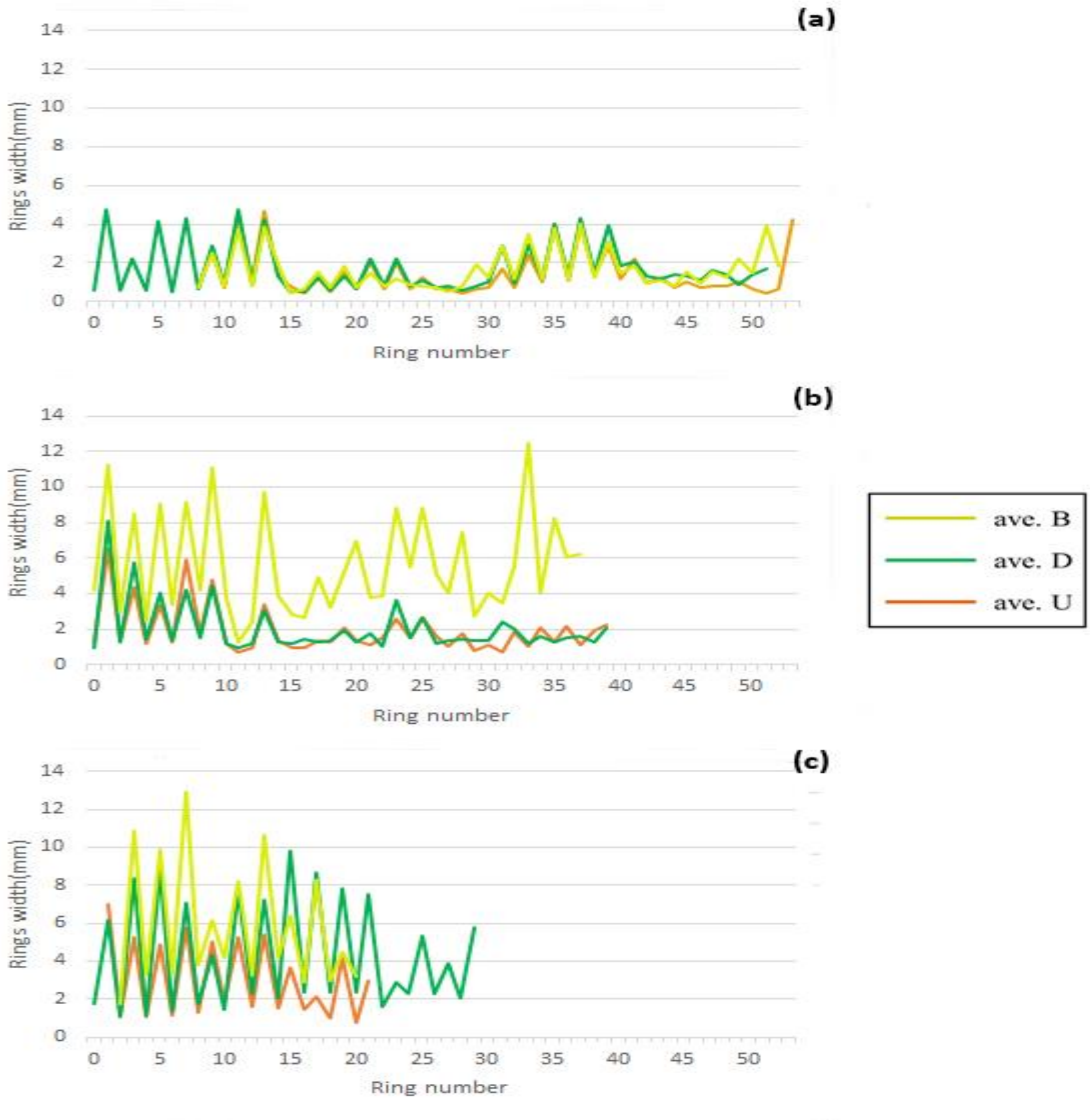


Figure 6. Comparison of averages in each regions of TARs (ave. B vs ave. D vs ave. U): (a) TAR I, (b) TAR II and (c) TAR III.

Due to approve of primary recorded value, averages of all recorded values in different regions of each TAR was calculated for samples. Fig. 3 illustrates average graphs for the three TARs.

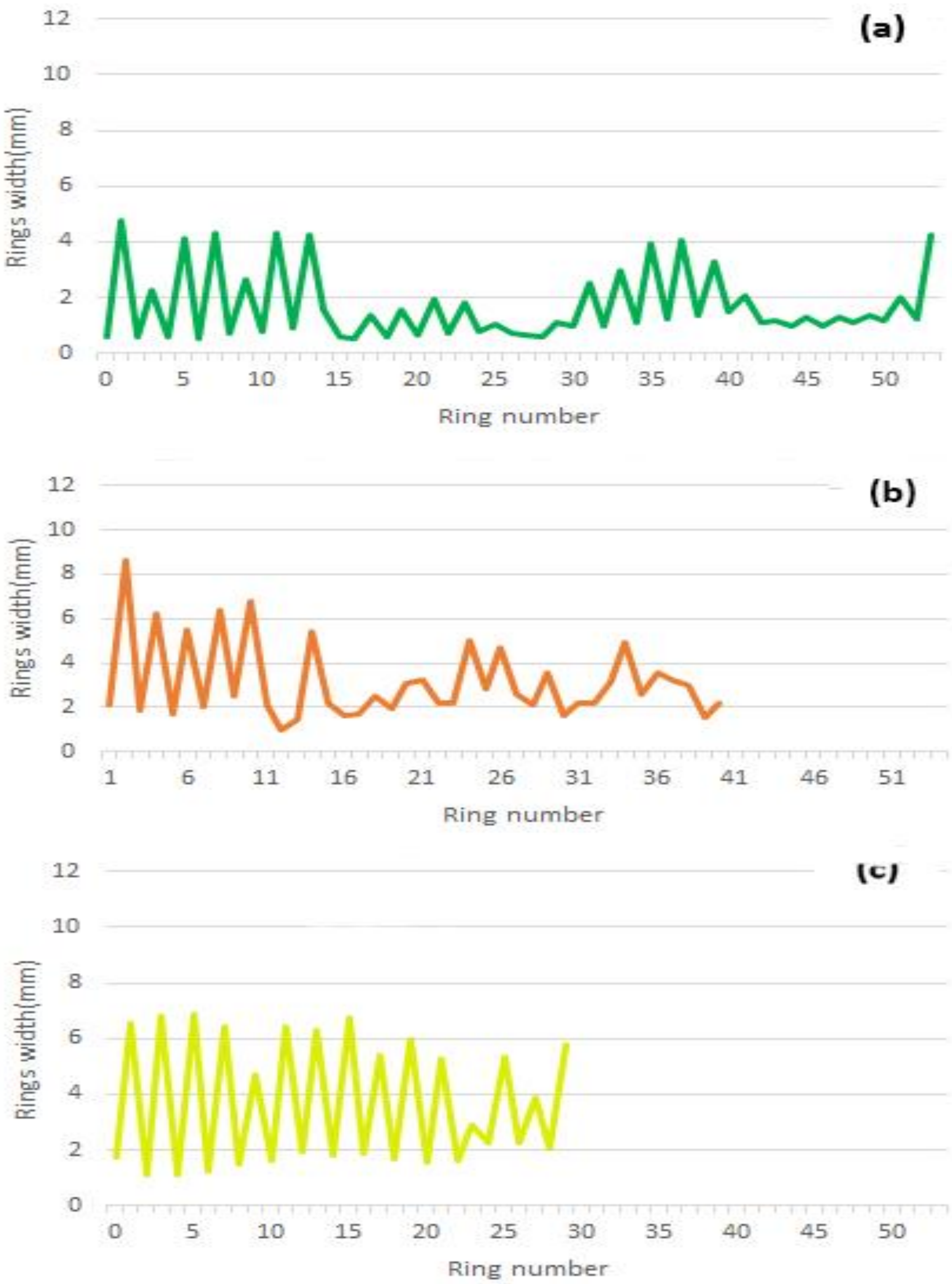


Figure 7. Average of Each TAR a) TAR I, b) TAR II and c) TAR III

Average graphs of different musical instruments were compared with *TSAP* software. Table 4 shows the related results which include of similarities and differences of different samples. *TAR I* was considered as a reference one in comparison with *TAR II*; then graph of *TAR II* moved along the reference graph to find the best matching condition. As Fig. 4a illustrates:

From 33nd rings (the start point) to last rings, fluctuate patterns are similar and Just minor incompatibilities exist in 45th rings.

These values are signs for authenticity of claimed *ABBAS TAR (TAR II)* due to similarity of used woods.

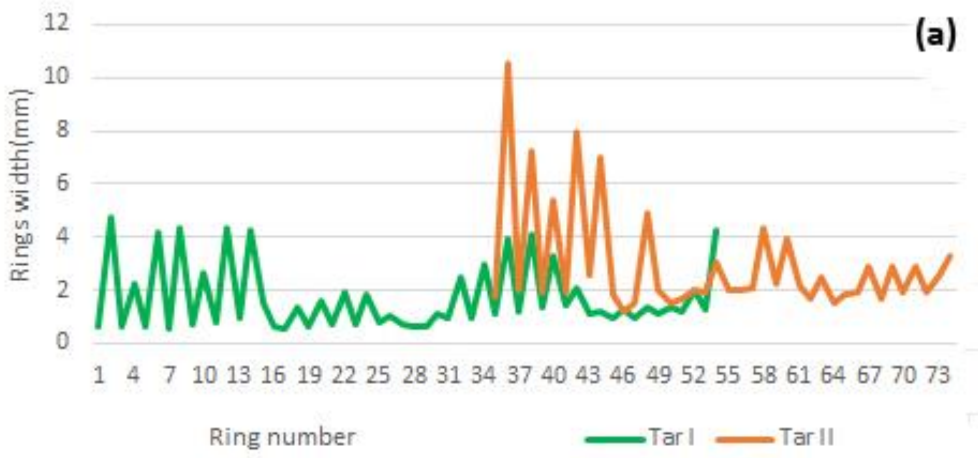
Table 3. Comparison of ring-width averages between TARs

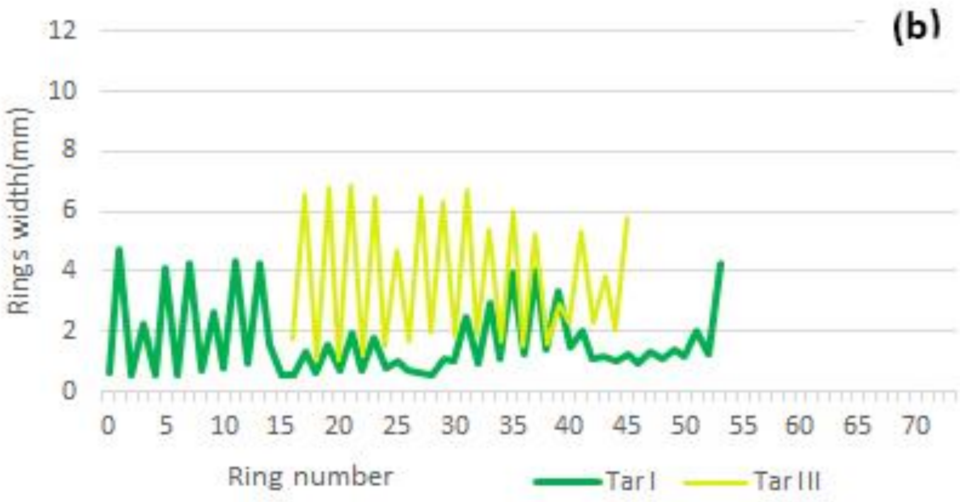
Sample	Ref.	Glk	GSL	%CC	TVBP	CDI
TAR I	TAR III	97	***	49	7.5	79
TAR I	TAR II	76	**	50	3.5	28
TAR II	TAR III	91	**	70	2.7	30

In comparison of *TAR I* and *TAR III*, the first sample was considered as a reference one. For accessing to the best matching condition, related graph of *TAR III* was moved along the *TAR I* graph. Higher widths in *TAR III* back to better growth condition of the origin tree. The following information could be concluded from comparison of these two graphs:

The start point of the comparsion is from the 16th ring, Similarity of two graphs patterns in 16th to 24th rings and also from the 31th ring to the last and small incompatibilities from the 24th ring to the 31th ring are observed.

According to these significant results we could suggest that a missing ring exist in wood of *TAR III* in 6th year. However, according to Table 4, there is high value of 97 for GLK and high significance GSL results (99.9%, significant level) and good similarity from 8th to 23th rings. This good matching and correlation are good primary signs that approve the probability of being the origin woods from similar regions. With considering the history of brothers, *ABBAS* and *JAFAR*, which lived in the similar period of time (about 1920 to 1965) in similar region, Isfahan, the concluded information approve authenticity of TARs making in aspects of time and place of primary used woods.





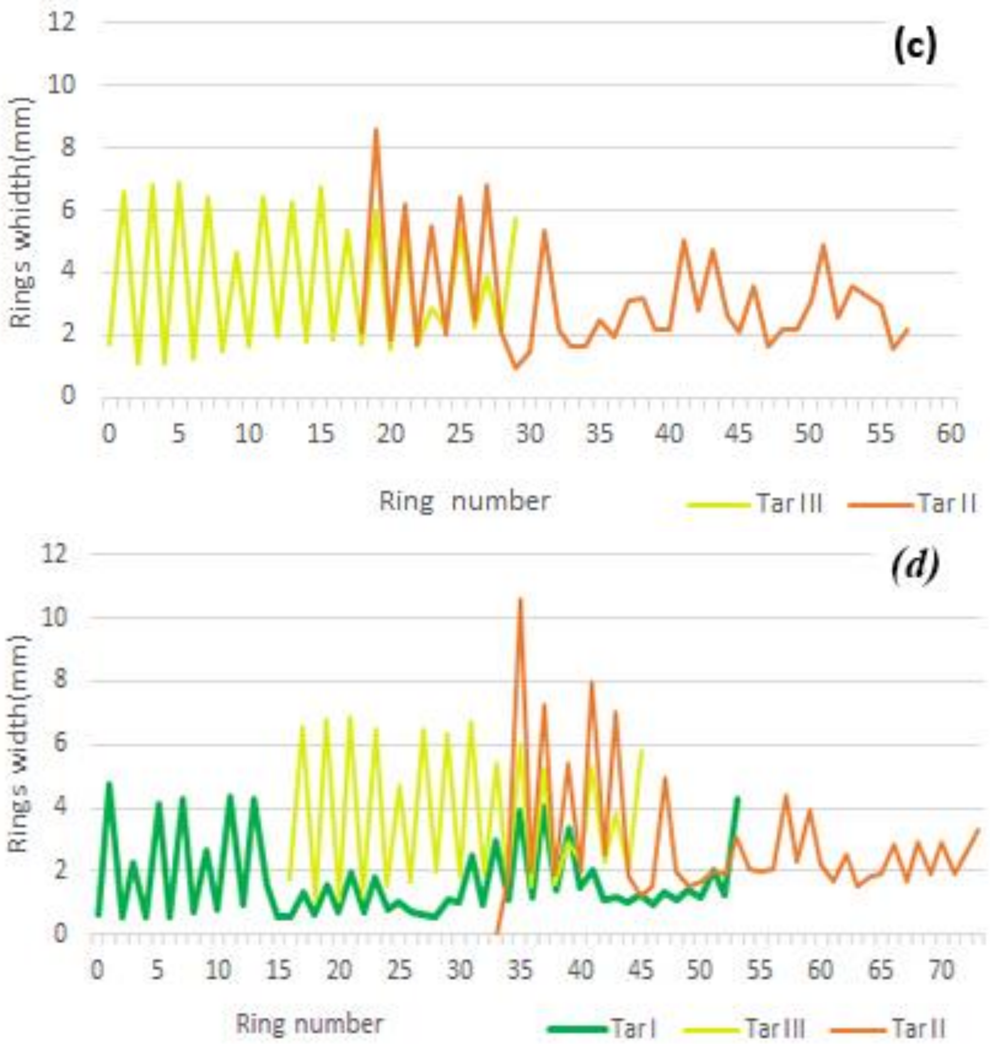


Figure 8. Comparison of different TARs a) TAR I with TAR II, b) TAR I with TAR III, and c) TAR II and TAR III and d) all TAR

Moreover, for higher confidence to concluded results, two claimed *TARs* (TAR II and III) were compared with each other. For this reason, *TAR III* was considered as a reference one and related graph of *TAR II* was moved for finding the highest matching condition. CDI=44 in 13rd ring of TAR II was the highest compatibility start point for two samples. In addition, GLK=76 and GSL significant in 95% but due to the compatibility of the graph together (Fig. 4d) The start point of the comparison is from the 19th ring (Fig. 4c) with CDI=30 and GLK=91 and GSL significant in 99% (Table 4) which approve that used woods are related to similar regions and periods of time.

Due do the fud the compatibility of the *TAR III* has started from the 16th ring and the compatibility of the *TAR II* has started from the 31th ring, *TAR II* can be resulted that the *TAR I* has the oldest wood and the *TAR II* has the newest wood.

According to the all above mentioned points and results, used woods in all three TARs are related to close time span and similar weather conditions. Because the claimed samples have high chronological similarity to the approved *ABBAS TAR* and while *ABBAS* and *JAFAR* brothers lived in similar period of time and in a same region, Isfahan, then, could chronologically conclude that *TARs* are original ones. Also, used woods in all three samples are related to similar regions that adds a positive signal for the originality of both samples.

4. CONCLUSION

In this study, dendrochronological method was used to investigate originality of two TARs that are maintained in Isfahan Music Museum and is claimed that appointed to *ABBAS* and *JAFAR*. Dendrochronology was applied measuring of rings width and comparison of values with a proved *ABBAS TAR* was considered. Results illustrated that chronologically all three samples are related to similar periods of time (in the mid-20th century), although *TAR I* is 17 years older than *TAR II* and 8 years older than TAR III.

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