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OBLICZA WOJNY
TOM 10 • NARZĘDZIA WOJNY
ŁÓDŹ 2023 • ISBN 978-83-8331-461-7 • s. 177–201
https://doi.org/10.18778/8331-461-7.11

JEWELS OF CRAFTS: FORGING BLADES, FLETCHING ARROWS, MAKING NAPHTHA, AND MANUFACTURING BLACK POWDER – A PERSIAN MANUSCRIPT ON WARFARE

Summary. The present article deals with an undated Persian manuscript titled *Javāher al-Sanāye'* جواهرالصنایع [*Jewels of Crafts*]. Many Persian manuscripts provide invaluable information on weapon-making, forging swords, archery techniques, attacking fortifications, casting cannons and making firearms, and military strategies. Most accounts on making crucible steel are part of books on jewels and stones. In my last book *Jewels and Patterned Crucible Steel: Books of Jewels, Stones, and Metals*, I provided a translation and annotation of the book *Goharnāmeh* [*Book of Jewels*] written by Mohammad ben Mansur for the ruler Uzun Hasan Āq Qoyonlu in the 15th century CE (9th century Hijra). The *Goharnāmeh* by Ben Mansur describes precious and semi-precious stones, animal products, and metals. An essential part of the book deals with blades and making crucible steel. However, the manuscript *Javāher al-Sanāye'* [*Jewels of Crafts*], which is the topic of this article, is about the transformation of stones and metals. The book describes how the craftsmen made crucible steel and expands on how ironworkers used crucibles for conducting other alchemical processes to change and transform the colour of stones, among other processes. *Javāher al-Sanāye'* [*Jewels of Crafts*] is a gem for war-related topics as it provides invaluable information on how to make crucible steel blades, how to identify and classify swords, how to make the adhesive glue for attaching the blade tang to the handle of the sword, how to make glue for fletching arrows, how to make naphtha (burning material) for attacking fortifications, and how to make the black powder.

Keywords: crucible steel, sword, arrow, naphtha, bow varnish, black powder, Persia, Iran, Medieval Era, dynasty

1. Introduction

The manuscript *Javāher al-Sanāye'* جواهرالصنایع [*Jewels of Crafts*] is written in Persian and is kept in the Library of Iranian Parliament with the number 2,849. Although the author does not identify himself in the manuscript, he notes that he describes one hundred sixty crafts in his book,[1] and that the book consists of forty parts, each divided into smaller chapters or sections. However, the author contradicts himself some sentences later by adding that his book consists of twenty-four parts, and each part contains several chapters. This inconsistency could be due to different reasons – the author could have used another manuscript as its source, or the scribe made a mistake in counting different parts/chapters of the book (assuming that the author and scribe were two distinct persons). The manuscript itself has 101 sheets, each consisting of 2 pages, for a total of 202 pages. Each page has thirteen sentences written in a beautiful *naste'aliq* script, with the titles of parts and chapters written in red. The book has unique topics. Although the book is written mainly in Persian, pages 97–100 are in Arabic.

M. Chatra'i assumes that some parts of these sheets written in the Arabic language could be a direct quote from Mohammad Zakariya Rāzi's works. Based on the prose style and collocations, Chatra'i assumes that the manuscript *Javāher al-Sanāye'* [*Jewels of Crafts*] was written during the Safavid period; however, he does not provide any hard evidence for this assumption.[2] Some pages have handwritten explanations added by an editor on the corner of some pages, quoting the books *Maxzan al-Adviyeh* [*Treasure of Medicines*] written in Persian by Mohammad Hossein Aqili Alavi Khorasani in 1771–1781 CE (1185–1195 Hijra) and *Qarābā Din* [*Graphidion*], dedicated to the study of traditional medicine, written in 1771 CE (1185 Hijra). These notes serve to explain some parts of the book and especially describe the suggested ingredients in the original manuscript.[3] Therefore, the manuscript was written before 1771 CE. Note that the Safavid period lasted from 1501 to 1736 CE. *Javāher al-Sanāye'* attributes some crafts and operations to some masters such as Master Filsuf al-Maqrebi (p. 5), Kālenj Hakim (p. 72), Yāquti Mosta'sami (p. 73), Ya'qub ibn Ishāq Kāraz (p. 75), and Master Evaz Mobser (p. 181). We do not have any further information about the mentioned masters to deduce more information about the correct dating of the manuscript.

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[1] M. Chatra'i, *Matni az Ruzegār Safaviyān dar Bāreye Honarhā va Sanāye'e Gunāgun*, "Payyām-e Bahārestān" 1390 [2011], vol. 3, no. 13, pp. 306–307.

[2] *Ibidem*.

[3] *Ibidem*.

2. Similar manuscripts

Two similar manuscripts in the collection, *Majma' al-Sanāye'* [*Assembly of Crafts*] and *Majmuat al-Sanāye'* [*Collection of Crafts*] (National Library and Archive of Iran, NLAI, numbers 12,248 and 15,617, respectively), deal with the same topic. Although Chatra'i identifies them as copies of the manuscript *Javāher al-Sanāye'*, a closer look at *Majmuat al-Sanāye'* which is dated by the NLAI to 1717 CE (1129 Hijra) reveals fundamental differences between these two manuscripts.[4] If we take the date of 1717 CE (1129 Hijra) proposed by the NLAI into account, this date places the manuscript in the Safavid period of Iran. Further, the NLAI identifies the manuscript number as 978f, in contradiction to the manuscript number 15,617 given by Chatra'i. *Majmuat al-Sanāye'*, with 110 pages, is almost half the length of *Javāher al-Sanāye'*. However, since each page of the manuscript *Majmuat al-Sanāye'* has 19 lines and each page of the manuscript *Javāher al-Sanāye'* has 13 lines, *Javāher al-Sanāye'* has a total of 2,626 lines, and *Majmuat al-Sanāye'* has 2,090 lines.

Regarding the possible author of the text, Chatra'i quotes Daneshpajuh who quotes the manuscript *Javāher al-Sanāye'* itself, naming its author as 'Mir Yahyā Hakim Filsuf Maqrebi.' However, Daneshpajuh does not offer any source for his claim.[5] Possibly, he thought that the name of Master Filsuf al-Maqrebi, who is mentioned in the text as one of the masters of the crafts, should be the author of the text. On the other hand, F. Qasemlu titles the same treatise as *Majmuat al-Sanāye'* [*Collection of Crafts*] written by Mir Yahyā or Hakim Filsuf Maqrebi in India.[6] *Majmuat al-Sanāye'* mentions the names of the following masters: Master Filsuf al-Maqrebi, Kāleh Hakim, Aflātun Hakim (a reference to the Greek philosopher Plato), Mohammad Zarkes, Ostād Hāji, Ostād Ayyāz, Ostād Sa'dāh, Ostād Avvaz Baqdādi, and Mobārak Šāh Ra'dandāz.[7] The text does not refer to any of them as the author of the text. The following table shows the differences between the two manuscripts discussed above:

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4 *Ibidem*.

5 *Ibidem*, pp. 306–307.

6 F. Qasemlu, *Javāhernāmeh*, [in:] *Encyclopaedia Islamica*, 2014 and Archives.

7 *Ibidem*.

Table 1

Comparisons of two manuscripts

Title	***Javāher al-Sanāye’*** **[*Jewels of Crafts*]** **جواهرالصنایع**	***Majmuat al-Sanāye’*** **[*Collection of Crafts*]** **مجموعهالصنایع**
Date	undated	Dated 1717 CE (1129 Hijra)
Provenance	Library of Iranian Parliament	National Library and Archives of Iran
Manuscript number	2,849	978f
Number of pages	202	110
Number of lines in each page	13	19
Total number of lines	2,626 lines	2,090 lines
Author	unknown	unknown
Number of parts	24 parts, each part containing one to several chapters	42 parts, each part containing one to several chapters
language	Persian; four pages (97–100) in Arabic	Persian
Mentioned Masters of the crafts	- Master Filsuf al-Maqrebi - Kālenj Hakim - Master Evaz Mobser - Yāquti Mosta’sami - Ya’qub ibn Ishāq Kāraz	- Master Filsuf al-Maqrebi - Kāleh Hakim - Aflātun Hakim - Mohammad Zarkes - Ostād Hāji - Ostād Ayyāz - Ostād Sa’dāh - Ostād Avvaz Baqdādi - Mobārak Šāh Ra’dandāz
Period editing	Comparisons to *Maxzan al-Adviyeh* [*Treasure of Medicines*] and *Qarābā Din* [*Graphidion*]	None

Source: Author's own elaboration.

3. Topics of the *Javāher al-Sanāye’* [*Jewels of Crafts*]

The book *Javāher al-Sanāye’* [*Jewels of Crafts*] has twenty-three parts. Most parts deal with how to make big pearls by gluing broken smaller parts together, how to dye rock crystal stones red so they resemble rubies and spinels, how to make cinnabar with the colour of rubies and spinels, how to purify lapis lazuli, how to enamel and make enamelled bowls, cups, and jugs, how to make different types of oxides (silver oxides, copper oxides), how to manufacture various types of alums, how to make different types of lead, silver, antimony, copper, iron, brass slags, and mercury, how to construct a dissolving pit and refractory cement, how to produce different types of colours for dyeing glasses and rock crystals, how to make putties, how to produce bezoars, how to melt gold to be used for calligraphy, how to dye and starch paper, how to colour ivory, how to make hair colours and how to have longer hair, how to decorate with silver and golden palms, and how to perform exotic sciences.

Fig. 1. A page of the manuscript *Javāher al-Sanāye'*
(Source: Library of Iranian Parliament, no. 2849)

The following parts of the book are relevant for the study of warfare:

- **Part nine** – About making foreign blades: The author explains how to make blades that are so flexible that they can be folded like a piece of paper. In addition, these blades are so sharp that they can pierce glass, cut iron, and pick up copper coins from the ground. This section consists of three chapters.

- **Part thirteen** – About attaching the feathers on arrows: The author explains that the feathers should be attached so tightly that even if the arrows were placed in water for ten days, the feathers would not become loose. This section consists of one chapter.
- **Part nineteen** – About making *eskandari* oil and fat and using them as burning materials for attacking fortifications.
- **Part twenty-three** – About making black powder for guns and fireworks.

3.1. Making blades and quenching processes

Part 9 provides invaluable information on forging blades and it describes two different forging methods. The first chapter of this part describes the following forging process:

> First chapter: To make foreign blades, they bring old iron horseshoes that have been used under the hooves of horses. They are placed on a strong fire, [melted] and made into one [piece]. Before placing [the piece] on the fire again, they immerse it in a solution of 'alkali stone.' Then they place it on fire and straighten it as far as they see fit. This way, they put the mass on the fire [again] and allow it to cool in the mentioned water [liquid]. They keep doing this until it is finished, it is flexible and soft, can be folded like paper, is sharp, and can cut glass and steel. It can pick up one deram coin from the ground.

The text mentions horseshoes as a significant material for making blades. The use of old horseshoes for making steel in general and blades in particular had a long tradition in Persia.

One of these manuals is the book *Ta'id Besarat* [*Aid to Sight*] written in Delhi in 1706–1707 CE (1118 Hijra) by a Persian named Mirzā Lotfallāh. He wrote his treatise *Ta'id Besarat* [*Aid to Sight*] on the sword, sword making, and sword analysis (*šamširšenāsi* شمشیرشناسی) under the pseudonym Nithār with the honorary epithet of Nosratallāh Xān. Mirzā Lotfallāh also talks about the use of horseshoes in making steel and distinguishes between two methods: a) the Hindustani method and b) the Gujarati method:

a) **Hindustani method**: The ironworkers use raw iron (*āhan-e xām*) also called 'used horseshoe' (*na'lpāre*) and a second type of iron, *kahiri,* to make steel. *Kahiri* is shining dark (*tirebarrāq*). They use various recipes to make steel.

b) **Gujarati method**: They do not use *sakileh* in Gujarat as they mix hard dark iron (*āhan saxttire*), which is known as the wise (*dānā*) in that region, in it [the crucible steel charge]. The difference in colour between the *kahiri* and the wise in blades is that the *kahiri* is shining dark similar to a jet stone or touchstone, and the dark iron is whitish dark (*tirebarrāq*) similar to the colour of burned lime. Although both types of iron are hard, as far as dryness is concerned, the wise is drier than the *kahiri*. If they melt the steel and try their best to melt the iron, the *sakileh* does not turn out right due to its hardness and the low quality of the wise.[8]

As we see above, the horseshoe is used in both methods, and they only differ in the usage of the second type of iron that is added to the used horseshoe. As the 19th-century French traveller to Persia Julien de Rochechouart reports, old horseshoes were also used in the process of making gun barrels. De Rochechouart reports that Persian smiths collected two old iron horseshoes and a certain quantity of small bits and pieces of ordinary iron. The total amounted to 15 *sirs*,[9] which is almost 1 kg. He further documents how the smiths layered the iron in such a way that the horse irons made up the exterior. The smiths placed the iron in the fire, and they heated it until it almost reached the melting point. In the next step, they forged the iron on the anvil until all the pieces became one uniform, compact mass. The smiths repeated the forging process several times. Then, they drew out the metal until it became a bar about 75 cm in length. They made 12 of these bars, attached them, and put the entire billet into the forge. After heating the billet sufficiently, they took the mass out and forged and cut it wherever the various parts had blended. The smiths stretched and reduced the billet to the size and thickness of a finger and rounded the corners. The next step involved taking four of these strips and twisting them into spirals, extending them on an iron blade, and beating and heating the mass until it was compact. Afterwards, the smiths twisted a mass of

[8] M.M. Khorasani, *Aid to Sight: A 17th-century Persian Treatise on Sword Classification from India*, Frankfurt am Main 2022.

[9] According to *The Digital Lexicon of Dehkhoda*, a *satir* is a weight measurement that means *sir* (garlic) and based on weight measurements of Tabriz, *satir* is 15 *methqal*. According to Emam Shushtari (*Tārix-e Megyāsāt va Nogud dar Hokumat-e Eslami*, Tehran 1961, pp. 44–45), two different weights were described as *methqal* during the Abbasid period. One of them was called *methqal Arabi* (Arabian *methqal*), also called *methqal shar'i*, and the other one was called *methqal Seirafi* or *methqal Bagdadi*. *Methqal Arabi* was equal to 4.265 grams, and *methqal Bagdadi* was equal to 4.948 grams. *Methqal Bagdadi* was the weight measurement used in Iran. Therefore, 15 *sir* is exactly 1113.30 grams, a little bit over 1 kg.

this last strip and beat and heated it to obtain the welding, whereupon they withdrew the mass, polishing and smoothing the interior of the gun barrel. In the next stage, they polished the exterior, covering the surface with a mixture of two parts sulphur and one part salt, which were mixed into a water solution. The smiths put the coated barrel in a hot and humid place, such as the interior of a bath, for 24 hours. At the end of that period, they took the barrel out, and it was complete.[10] As we see, the process of making the gun barrel also involved adding ordinary iron to two old horseshoe irons. The same process of making pattern-welded steel was used for making gun barrels in Iran.[11]

In the second chapter, the author describes the process of making finely curved (*mehrābi*) and Egyptian (*mesri*) blades. He writes:

> They take five sir of old and used horseshoes as mentioned before and make two discs of them. They make eight to nine holes in each iron disc. Then they take four deram of tin, four deram of marcasite, two deram of sieved and heated mercury, two deram of small pieces of copper, and ten deram of lead. Then they add tin, small pieces of copper, and mercury, and heat them to a melting point. Then they add mercury and marcasite and mix and add them to the openings of iron discs. Then they attach two discs by placing them on each other. They close all the openings very tightly and place them under the sunlight so that they dry up. Then they place them in the fire, and when they reach a red colour, they take them out and hammer them so that both discs become one [piece]. Then they cut it into two halves and make two discs again. They make holes in them and add the second disc as mentioned before. Then they close all openings and dry and heat it again until it turns red. They take it out, hammer it, make two discs of it, add the ingredients and repeat the whole process ten times. Then they make blades of the round iron in the shape of an Egyptian [blade]. They also make dešne daggers, knives, and daggers. This is the Egyptian method. Foreign knives which are brought here are also made of this round iron. This sword is better than the Egyptian sword as they need to polish the Egyptian sword, but this sword does not need polishing. Even if they put it *daršekāl* in water, it does not change colour. These swords are only made for kings and are kept in royal treasuries.

Based on the text, we can make the following calculation: 5 *sir* x 15 *mesqāl* x 4.948 grams = 371.10 grams. Thus, the text suggests using 371.19 grams of a horseshoe to make an iron disc. Additionally, as the text recommends using two iron discs, the amount of used iron adds up to 371.19 x 2 = 742.2 grams.

10 W. Floor, *Traditional Crafts in Qajar Iran (1800–1925)*, Costa Mesa 2003.

11 M.M. Khorasani, *Persian Fire and Steel: Historical Firearms of Iran*, Frankfurt am Main 2018.

Iron gained from used horseshoes, however, was not the only material added to the charge. The text also describes adding metals such as tin, mercury, copper, and lead. The mineral marcasite is also added after making nine holes in each iron disc. The text describes using the weight measurement *deram* to measure the ingredients. These include four *deram* of tin, four *deram* of marcasite, two *deram* of sieved and heated mercury, two *deram* of small pieces of copper, and ten *deram* of lead. The weight measurement *deram* (or *derham)* is 6 *dāng*, each *dāng* is two *qirāt*, each *qirāt* is two *tasuh*, and each *tasuh* is equal to two average barleycorns in weight. In other words, each *derham* is equal to the weight of 48 average barleycorns.[12] We know that since antiquity, grains of barley or wheat have been used by traders to specify units of mass. It is hard to define the exact weight of a grain of barley used in such a system, but the modern average weight is circa 65 mg. Thus, each *deram* is equal to 1 x 6 x 2 x 2 x 2 x 0.065 = 3.12 grams. The following table shows the calculated amount of each item in grams as described in the text.

Table 2

Type of ingredients and their respective amount added to the crucible charge

Ingredient	Amount in *deram*	Amount in grams
Lead	10 *deram*	10 x 3.12 = 31.2 grams
Tin	4 *deram*	4 x 3.12 = 12.48 grams
Marcasite	4 *deram*	4 x 3.12 = 12.48 grams
Mercury	2 *deram*	2 x 3.,12 = 6.24 grams
Copper	2 *deram*	2 x 3.12 = 6.24 grams
The total amount of ingredients added to the charge		68.64 grams

Source: Author's own elaboration.

Using these calculations, the whole charge together with added ingredients amounts to:

742.2 grams of iron gained from horseshoes + 68.64 grams of added ingredients = 810.84 grams total.

[12] M.M. Khorasani, *Lexicon of Arms and Armor from Iran: A Study of Symbols and Terminology*, Tübingen 2010, p. 225.

Other Persian treatises also discuss adding copper to the crucible charge. In the *Ādāb al-Harb va al-Šojā-e* [*Customs of War and Bravery*] written in Lahore or Delhi in 1229 CE (626 Hijra) or 1230 CE (627 Hijra), Mobārak Šāh talks about adding silver and copper to the steel charge. He specifically says that to make *benāh* blade, master smiths add copper and silver to *narmāhan* نرم‌آهن [soft iron]. It results in having steel with larger patterns. He adds that the wound inflicted by this kind of sword does not heal easily.[13]

In the *Ta'id Besārat*, Mirzā Lotfallāh also mentions adding silver to the crucible steel charge. He writes that by adding silver to the charge, the steel obtains a good pattern. Therefore, in Arlase, they mix silver in the charge. The more silver they add, the more expensive it becomes. The precious steel was exported to the trusteeship (*velāyat*, possibly Iran). If they add gold, the pattern becomes golden. But because adding gold is very expensive, it is rare. Mirzā Lotfallāh adds that the steel pattern is first due to the addition of silver and second due to other ingredients in the mixture. Further, Mirzā Lotfallāh adds that the practical blade has hard iron in its nature, in contrast to the noble blade that has soft iron. Its 'softness' (flexibility) is because of the presence of silver, which is a bit soft, but hardens during the quenching process. Mirzā Lotfallāh also says that the high quality of the noble iron is because of the presence of silver. He explains that the iron of the noble blade is very oily and soft in its nature. If the iron of the practical blade is heated extensively, its flexibility disappears, and it becomes darkish white like tin; if it is heated moderately, it remains hard and dark.[14]

In 1841 CE, Captain Massalski published the process of making crucible steel in French in a Russian mining journal. He describes the process of adding silver to the crucible steel charge.[15] Massalski distinguishes between three metals used for making this type of steel: iron, cast iron, and silver. He stresses that their proportions depend on the quality of each component. The iron used in the recipe is recycled from old nails, steel plates, and other objects that are cleaned of rust. Cast iron should be of the best quality. The silver must also be pure and of very high quality. Massalski stresses that the normal proportion is one part cast iron and

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[13] M.M. Khorasani, *Aid to Sight*... For another translation, *vide*: R. Elgood, *Rajput Arms & Armour: The Rathores & Their Armoury at Jodhpur Fort,* vol. 1–2, New Delhi 2017.

[14] M.M. Khorasani, *Aid to Sight*...

[15] W. Floor, *op. cit.*; J. Allan, B. Gilmour, *Persian Steel: The Tanavoli Collection*, Oxford 2000.

three parts iron, measured according to weight. Iron and cast iron are reduced to small pieces and mixed thoroughly, and then the mixture is poured into refractory crucibles. The dimension of these crucibles is fivefold the height, fourfold the outer, and threefold the interior diameter depending on the amount of steel one wants to make. In Iran, the quantity was usually ¼ to 1 *batman* (2.46 kg). Massalski describes the base of the crucible as slightly concave. The mixture amounts to 1/3 of the crucible's capacity.[16] Eyewitnesses traveling to India across centuries reported adding gold and more commonly silver to a steel blade.[17] Another reason for adding silver to the steel charge was to make it auspicious.[18]

Additionally, historical Persian texts report on making an alloy by mixing different metals. For example, in the treatise *Goharnāmeh* [*Book of Jewels*], Ben Mansur talks about an alloy named *haftjuš* that consists of seven metals: iron, silver, copper, lead, gold, zinc, and tin.[19] The book *Javāher al-Sanāye'* [*Jewels of Crafts*] also talks about mixing five metals – iron, copper, tin, lead, and mercury – to make steel.

Table 3

Metals added to the crucible charge to make steel based on two different manuscripts

Metals	**iron**	**silver**	**copper**	**lead**	**tin**	**gold**	**zinc**	**mercury**
Goharnāmeh [*Book of Jewels*]	present	present	present	present	present	present	present	absent
Javāher al-Sanāye' [*Jewels of Crafts*]	present	absent	present	present	present	absent	absent	present

Source: Author's own elaboration.

The treatise *Javāher al-Sanāye'* [*Jewels of Crafts*] recommends only marcasite as a mineral that should be added to the charge of metals. Other Persian manuscripts specify more ingredients that should be mixed with iron. These

16 M.M. Khorasani, *Arms and Armor from Iran: The Bronze Age to the End of the Qajar Period*, Tübingen 2006; W. Floor, *op. cit.*, p. 452.

17 R. Elgood, *op. cit.*, vol. 1, p. 22.

18 *Ibidem*.

19 M.M. Khorasani, *Jewels and Patterned Crucible Steel: Books of Jewels, Stones, and Metals*, Frankfurt am Main 2021.

ingredients were added to the iron and heated so that they melt better. They either contain carbon from different types of plants and fruits, such as oak apples,[20] pomegranate peel,[21] sour pomegranate,[22] or myrobalan,[23] or they contain lime (calcium carbonate), such as mother pearl,[24] or coral.[25] Other ingredients can also provide the crucible charge with both lime and carbon, such as bone, shell, etc. Persian manuscripts also report about the use of a coloured soft stone or clay named manganese,[26] famed for its use in glassmaking. The glass melts early on in the process and protects the molten mass from oxidisation and the creation of bubbles. Some manuscripts also report on the usage of flux, which also helps keep the charge from oxidising.[27] The flux mixes with the oxides and together they lower the melting temperature and the viscosity of the oxides. They also used marcasite and lava stone for the same purpose.[28] Other Persian treatises also talk about the usage of various organic materials, such as leather and sheep liver, and insects such as *Peganum harmala*.[29] Both have clear carbon content, and it shows that ancient Persian smiths knew exactly what they were doing with the crucibles. Although they did not have the scientific methods of today, centuries of practical experience helped them conduct complex operations to create watered steel blades.

The third chapter of part nine of *Javāher al-Sanāye'* talks about how to quench blades, arrowheads, and spearheads in such a way that they cause mortal wounds that cannot be healed. The text differentiates between six types of quenching although it numbers only two methods first, and mentions the rest without numbering them. The first type describes a process of making molten steel in a crucible and a type of quenching process for cooling the heated crucibles. The text states:

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[20] O.E. Khayyām-e Neišāburi, *Noruznāme*, annotated by A. Hosuri, Tehran 2003.

[21] M.A.B. Johari Nezāmi, *Javāhernāme-ye Nezāmi*, annotated by I. Afšār, Tehran 2004.

[22] A.M.H. Šarif Mohammad, Untitled Manuscript. Attributed to the period of Šāh Esmā'il Safavid (1502–1524 CE), Tehran.

[23] M.A.B. Johari Nezāmi, *op. cit.*; A.M.H. Šarif Mohammad, *op. cit.* (original manuscript).

[24] M.A.B. Johari Nezami, *op. cit.*; O.E. Khayyām-e Neišāburi, *op. cit.*, p. 53.

[25] O.E. Khayyām-e NeišāburI, *op. cit.*, p. 53.

[26] M.A.B. Johari Nezami, *op. cit.*, pp. 326–327; O.E. Khayyām-e Neišāburi, *op. cit.*, p. 53.

[27] M.A.B. Johari Nezami, *op. cit.*, pp. 326–327.

[28] *Ibidem*.

[29] O.E. Khayyām-e Neišāburi, *op. cit.*

> First type: To make blades, arrowheads, and spearheads, they take and add ten parts iron, three parts verdigris, and three parts of a mixture of patinated tin, lead, and brass. Then they mix up all three [main] parts [iron, verdigris, and patinated tin, lead and brass] well and place them in a big crucible. They add borax to it and place it in a strong fire. Then they place the crucible in the urine of a donkey so that it cools. They repeat the same process with that piece of iron three times. Then they can make any type of weapon with that iron. The slightest injury caused by it will lead to certain death, and there will be no medicament for healing its injury.

As we see, the text suggests mixing ten parts of iron, three parts of verdigris, and three parts of a mixture of patinated tin, lead, and brass. They should be mixed well and then placed in a crucible. Then, they add borax (*tankār*) to the mixture and place it on a strong fire so that the whole mixture melts. In contrast to other recipes in which the heated crucibles were left to cool slowly by being exposed to the air in a furnace that was turned off, the *Javāher al-Sanāye'* describes a process where the heated crucibles were cooled in the donkey's urine. The text does not describe at which temperatures the heated crucibles should be placed in urine. We know that air exposure was done slowly, so as not to crack the crucibles.

The second process is applied to cold blades. The text describes the following:

> Second type: In quenching without using fire. If they want to be successful and victorious in any war, they take the plant extract and grind it in vinegar. Then they add salammoniac and dissolve all in naphtha. Then they get a piece of cotton, immerse it in the solution and rub it seven times on the [blade of the] weapon and dry it in the shade. It makes it very sharp and well quenched even without using fire. So that it can cut iron and glass and when taken in any war, it will lead to victory.

The plant extract described as *saber* is the extract of the Ilvā tree, which is bitter and grows in India.[30] They add Sal ammoniac to the extract, and then dissolve the mixture in naphtha to prepare the quenching liquid. The solution is applied seven times to the cold blade to quench it.

The third method for quenching involves a heating method. The text states:

> Another method to quench weapons: They mix mud, limestone, acanthus and dung together, and pound them and moisten them with donkey urine. Then they

[30] *Digital Lexicon of Dehkhodā*, https://www.parsi.wiki/ (access: 12 IV 2022).

> rub [this mixture] on blades and weapons, then they heat them, and cool them in alkali stone liquid. This results in a quenching which inflicts mortal injuries on the enemy within one hour even if the injury is as big as a needle head.

The *Javāher al-Sanāye'* describes pounding and mixing mud, limestone, acanthus, and dung. Then they moisten them with donkey urine. Then they apply the paste to blades and then heat the blades and quench them in alkali stone liquid.

The text also provides a fourth method for quenching the blades. This method involves heating the blade as well and is as follows:

> Another method: They mix mud and donkey dung and mix both with Doronicum scorpioides and moisten the mixture with donkey urine. They rub this mixture on any weapon, heat it, and then add Doronicum scorpioides to donkey urine [again] and then immerse the weapon in the liquid. It becomes such that any injury caused by it never heals.

This method consists of mixing mud, donkey's dung, and Doronicum scorpioides. In the next step, they added the donkey urine to the mix. They apply the paste to the blade and coat it with the mixture. Then they add Doronicum scorpioides to donkey urine and immerse the coated blade in it, and quench it.

The fifth method is quenching the blade in a cold state again. The *Javāher al-Sanāye'* describes this method as: "Another method: Quenching a weapon which is special, they rub Yemenite alum and mined Sal ammoniac and dissolve them in water. When they apply it to any weapon, it becomes quenched and gets a nice appearance".

The fifth method recommends mixing Yemenite alum with mined Sal ammoniac in water and applying the liquid to the blade. The sixth method suggests putting a mixture on a heated blade:

> Another method of quenching a blade so that if an injury is caused by it, it does not heal well and causes itching. They take clay and wet donkey dung and mix them and apply the mixture to the blade. Then they heat the blade and quench it so that it becomes sharp and the injuries [caused by it] do not heal.

This method involves mixing clay and wet donkey dung and coating the blade with the mixture. Then they heat the blade and quench it.

As we have seen, *Javāher al-Sanāye'* differentiates between three methods of quenching: a) quenching in the crucible, b) quenching the heated blade, and

c) quenching the cold blade. Additionally, the author proposes the use of different liquids for various quenching processes: a) donkey's urine, b) alkali stone liquid, c) naphtha, and d) water. As far as the ingredients for the heated and cold processes are concerned, the author suggests the following ingredients for different processes: a) animal products: dung, donkey urine; b) plants: acanthus, extract of the Ilvā tree, Doronicum scorpioides; and c) minerals: mud, limestone, alkali stone, clay, naphtha, Sal ammoniac, Yemenite alum. The following table shows the specific details for each quenching process:

Table 4

Different quenching methods described in *Javāher al-Sanāye'*

<table>
<tr><td colspan="7">Quenching in the crucible</td></tr>
<tr><td rowspan="2">First method</td><td colspan="4">Ingredients in the crucible</td><td colspan="2">Quenching element</td></tr>
<tr><td colspan="4">Ten parts iron, three parts of verdigris, and three parts of a mixture of patinated tin, lead, and brass.</td><td colspan="2">donkey urine</td></tr>
<tr><td colspan="7">Quenching the heated blade</td></tr>
<tr><td>Third method</td><td>mud</td><td>limestone</td><td>acanthus</td><td>dung</td><td>donkey urine</td><td>alkali stone liquid</td></tr>
<tr><td>Sixth method</td><td colspan="3">clay</td><td colspan="3">wet donkey dung</td></tr>
<tr><td colspan="7">Quenching the cold blade</td></tr>
<tr><td rowspan="2">Second method</td><td colspan="6">Ingredients</td></tr>
<tr><td colspan="2">extract of the Ilvā tree</td><td>Sal ammoniac</td><td colspan="3">naphtha</td></tr>
<tr><td>Fourth method</td><td colspan="2">donkey dung</td><td>mud</td><td colspan="2">Doronicum scorpioides</td><td>donkey urine</td></tr>
<tr><td>Fifth method</td><td colspan="2">Yemenite alum</td><td colspan="3">mined Sal ammoniac</td><td>water</td></tr>
</table>

Source: Author's own elaboration.

Other Persian manuals also describe how the quenching process affects the colour of patterned crucible steel as well. Colour is one of the most important factors in distinguishing the quality of patterned crucible steel. In the *Aid to Sight: A 17th-century Persian Treatise on Sword Classification from India*, Mirzā Lotfallāh states that the main difference between the good quality of noble and the lesser quality of practical blades is due to the quenching process. Mirzā

Lotfallāh stresses that if they quench the blade correctly, the colour of each sword will have the proper colour. If they do not quench the blade properly, the colour will change accordingly.[31] This is very essential information as many restorers and collectors of today believe that the colour of patterned steel is due to the etching process only. Although *Javāher al-Sanāye'* does not talk about the effects of quenching on the blade colour, other Persian manuscripts report on how the quenching process can influence the colour of the blade.

- **Red colour:** In the *Tohfat al-Qarāyeb*, al-Hāseb al-Tabari reports that the smiths should use blue vitriol (copper sulfate) and green vitriol (ferrous sulfate) in the quenching process to make the blade red.[32] In an untitled manuscript, Šarif Mohammad reports that they should use old clear vinegar, copper oxide, and yellow vitriol in the quenching process to make the blade red.[33] In the *Bayān al-Sanā'āt*, Taflisi states that they should use blue vitriol and green vitriol in the quenching process to make the blade red.[34]
- **Yellow colour:** To make the blade yellow, al-Hāseb al-Tabari explains that the smiths should use yellow vitriol in the quenching process.[35] Taflisi states that they need to use blue vitriol to make the blade yellow.[36]
- **Green colour:** To make the blade green, al-Hāseb al-Tabari states that smiths should use leeches, *Cichorium intybus*, vitriol, and cow gall bladder.[37] To make the blade green, Taflisi states that the smiths should use *Cichorium intybus* and white vitriol.[38]

3.2. Attaching feathers to arrow shafts

Part thirteen of the treatise *Javāher al-Sanāye'* deals with the important topic of attaching feathers to arrow shafts. The text describes:

[31] M.M. Khorasani, *Aid to Sight*...

[32] M.A. Al-Hāseb Al-Tabari, *Tohfat al-Qarāyeb*, Tehran 1992 (original manuscript).

[33] A.M.H. Šarif Mohammad, *op. cit.*

[34] H.E.M. Taflisi, *Bayān al-Sanā'āt*, [in:] *Farhang-e Irān Zamin*, vol. 5, second edition, Teheran 1354 [1975], p. 317.

[35] M.A. Al-Hāseb Al-Tabari, *op. cit.*

[36] H.E.M. Taflisi, *op. cit.*, p. 317.

[37] M.A. Al-Hāseb Al-Tabari, *op. cit.*

[38] H.E.M. Taflisi, *op. cit.*, p. 317.

> Part thirteen: on attaching the feathers to arrows so that even if they [the arrows] are placed in water for ten days the feathers do not detach and get wasted. This consists of one chapter. They take one and a half parts of casein glue as mentioned before, one part of fish glue, and one part of oil for making the bow (sandarac oil). First, they place fish glue in water and heat it over fire so that it is dissolved. They sieve and clean it [the liquid]. Then they add bow oil so that they become one. They place casein glue in [a mixture of] limestone liquid and egg white. Then they add fish glue and sandarac oil. They rub the whole with a stone so that they are mixed well. Then they place it on arrow feathers and arrow shaft [and stick them together]. When it dries and cools, the feathers do not detach anymore.

Table 5

Ingredients for making the glue for attaching feathers to the arrow shafts

Ingredients				
Bow varnish *roqan-e kamān*	Fish glue *serišom-e māhi*	Casein glue (*serišom-e panir*)	Limestone liquid *āb-e āhak*	Egg white *sefideh beyzeh*

Source: Author's own elaboration.

In making and preserving the bow, a special oil (*roqan kamān* or bow varnish) was used. This was a transparent, yellowish resin[39] that was called sandarac.[40] The bow oil was derived from the small tree *Tetraclinis articulata*. Its resin was used as oil for varnishing bows. Generally, the bow oil is a mixture of resins and oil melted together.[41] The treatise *Jāme al-Hadāyat Fi Elm al-Romāyat* [*Complete Guide Concerning the Science of Archery*] dated 1574 CE (982 Hijra) mentions this type of bow varnish concerning Damascus arrows for use at sea: "The arrow is made of wood, of 'sandalwood.' Unless it is good and chosen carefully, the master does not use the tendon for attachment. Instead of the tendon, they twist 'silk' around the arrow, and instead of the natural glue they use 'bow varnish.' This is called the 'sandarac arrow'."[42]

[39] *Digital Lexicon of Dehkhodā*, https://www.parsi.wiki/ (access: 25 V 2022).

[40] A. Ma'tufi, *Tārikhe* Čāhr *Hezār Sāleye Arteš Irān: Az Tamaddon Ilām Tā 1320 Khoršidi, Jange Irān Va Arāq*, vol. 1–2, Tehran 1999.

[41] M.M. Khorasani, *Arms*..., pp. 294–295.

[42] B. Dwyer, M.M. Khorasani, *Jāme al-Hadāyat Fi Elm al-Romāyat* [*Complete Guide Concerning the Science of Archery*] *by Nezāmeldin Ahmad ben Mohammad ben Ahmad Šojāeldin Dorudbāši Beyhaqi*, "*Quaderni Asiatici*" 2012, no. 97, pp. 45–60.

The quality of the glue was extremely important for the bowyers since it held the component materials of a composite bow together even under great strain.[43] There were four different forms of glue: a) tendon/sinew glue, b) ear and hide glue, c) fish glue, and d) a mixture of fish and sinew glue.[44] The text of the treatise *Javāher al-Sanāye'* mentions only fish glue among four types of glue. Therefore, I will summarise it here. Based on Kani [the famed Ottoman archery expert], fish glue was almost of equal quality to tendon/sinew glue. It was made from the skin of the palate of the Danube sturgeon. In other cultures, glue from the air bladder of fish was widely used. The size of the palate skin depends on the size of the fish and can be up to two hands. It is translucent, whitish sugar-coloured, and as strong as leather. To obtain the skin, a circular incision was made, and the skin was pulled out. Then, the skin pieces were dried. To obtain the glue, the bowyer soaked the skins in water for 24 hours. After that, he stacked several pieces on a marble block and pounded them with a wooden club. The club was frequently moistened with saliva since it was believed that moistening with water adversely affected the quality of the glue. After the mass became thin as a result of continuous striking, circular pieces were cut from the sheet. These were dried and used as glue. To use them, the bowyer cut them into pieces and dissolved them in clean water over a charcoal fire.[45]

Javāher al-Sanāye' discusses the third ingredient, casein glue, in chapter three of part five of the book. It reads as follows:

> The third chapter is about making casein glue and dissolving bodies that are used for dyeing; there are six types. The first type: About the characteristics of casein glue, which is an exotic and secret science. But it is a necessity to explain, as most operations in this book are done with the help of this type of natural glue. There is only one way. They bring fresh casein, as much as they wish, and cut it into narrow long pieces. The narrower the width the better it is. They bring a clean wooden plank and place it on a level surface. They mix the casein pieces in dried limestone liquid and place them at the bottom of a crucible. Then they place another wooden plank on it. Then they place a heavy stone on the wooden plank of the same length and width in the sun. The heavier the stone the better it is. After ten days, they take them out and wash them so that they can wash off all traces of limestone. They place them in the sun for the whole day. After its water is vaporised, the fat appears. Like the first

[43] P.E. Klopsteg, *Turkish Archery and the Composite Bow: A Review of an Old Chapter in the Chronicles of Archery and a Modern Interpretation*, Evanston 1947, p. 24.

[44] *Ibidem*, p. 40.

[45] *Ibidem*. Also *vide*: M.M. Khorasani, *Arms*...

time, they add the limestone as before. Then they place the same wooden planks and stone on them as mentioned before. They do it as long as it is required. They keep them for seven days and on the eighth day, they take them out and wash them with hot water and clean them with white fabric. They keep them in the sun for the whole day. On the next day, they place them in a big cauldron and put on it a trivet. They add salt water to it and place the [casein] pieces in it. They burn fire under it and boil it. After the water vaporises, they add salt water again and keep boiling it for the whole day. Then they take them out and wash them with fresh water. They clean them in fabric and dry them in the sun for the whole day. Then they boil them in salt water again. As mentioned before, they clean them with fresh water and a piece of fabric. Then they dry them in the sun. They keep the dust away. They keep doing this process a couple of times so that no fat from the casein appears in the sunlight. If it appears, they repeat the whole process so that its fat and redness disappear. It should look like 'limestone clay.' They grind them into mill powder. They place it in a glass vessel and keep the dust away and that is an absolute requirement. When they want to use it, they bring fresh white egg (albumen) and place it in a container and stir it. They take its foam and keep stirring it a couple of times so that it starts to shine and it does not foam anymore. They place a bit of that casein on [a polishing stone made of] porphyry or 'polisher made of glass' and add the white egg by dropping it and rubbing them together. They keep doing it until the mixture sticks to the lower stone. If they want it to get more fluid, they dissolve dried limestone in water so that the water looks like a 'yogurt drink.' They distill it with great care and add some of that water to it and rub it so that it becomes fluid and is not very thick. Then they can use it the way they want. To use it, they dissolve the powder of casein [in water]. If it remains more than one hour, it becomes hard, and they cannot scratch it with anything and they cannot take pieces of it out. This is the glue and it is so hard that it neither boils in water nor does it burn in fire. Iron cannot penetrate it and no gun, no arrow, no spear/lance, and no push-dagger can damage it. If they make shields, kotalhāyejanneh [meaning of this word is unknown], atkarkahi [meaning of this word is unknown], armguards, helmets, *kančom* [meaning of this word is unknown], or similar things they will be very hard, light, and flexible, and nothing can penetrate them. One cannot even imagine all things that can be made of this. It is a rarity that is unprecedented. It is a common and tested method.[46]

Swordmakers also used casein glue to attach the crossguard of a *šamšir* (sword) to the blade tang. It is one of the strongest glues I have ever encountered. We have replicated the casein glue based on the above recipe.[47]

[46] This part of the text was translated and published by the author and replicated already. For the whole process of replication, *vide*: M.M. Khorasani, N. Arjmandi, *Structural Analysis of Handles of Highly Curved Iranian Swords*, "Kafkas University Journal of the Institute of Social Sciences" 2020, no. 26, pp. 725–745.

[47] *Ibidem*.

3.3. Making black powder

Chapter one of part twenty-three of the treatise *Javāher al-Sanāye'* provides information on how to make black powder for guns and fireworks. Although the recipe for making black powder for guns is very short, the treatise provides detailed information on the component parts of black powder for different types of fireworks. As the present article deals with warfare, I concentrate only on the recommendation of the text for making black powder for guns. Part twenty-three has a short description of how to make black powder or gunpowder. The text reads: "Another type: Powder mixture for gun: They take two parts and five sir saltpeter, one sir charcoal, and three parts sulphur".

As it was explained before, a *sir* is equal to 15 *mesqāl,* and each *mesqāl* is equal to 4.948 grams. The text uses the term *pare* which means 'part,' and it is not clear what type of measurement the author refers to. We should note that making gunpowder was a tedious process: first, saltpeter was scraped from the walls of stables. Because this source was insufficient, urine and dung was collected so valuable nitrates could be extracted from it. To extract saltpeter from urine, gunpowder manufacturers established niter beds made of straw and filtered the urine through the straw, concentrating the salts for easy collection. Fortunately, there is an account of how Baxtiyāri tribes made gunpowder in Iran. It reads:

> In places such as caves or stables where they keep domestic animals with a floor made of rocks, after a while a layer of sheep waste is created. Due to the hard nature of the rocks, only the urine of domestic animals penetrates the rocks and stays there. One collects that layer in the fall and moistens it with water. Then one places the collected liquid in a hemp bag or a canvas nosebag. Then one hangs the bag and places a container below it to collect the liquid. Then one adds boiled water to the residue to remove the rest as far as possible. Then one places the liquid in a pot and boils it above a fire until all the water evaporates; then one places the thick liquid on a tray or wooden plank so that the liquid gets cold. When it is cold, one can see salt-like crusts which build up the sediments with a water layer on top. One removes the water and lets the tray dry under the sun. Then they dry up the gained salt-like sediments and they add willow charcoal with a weight of 20% of the weight of salt-like sediments, which is made from willow wood without any knots. Then with 20% of the weight of the salt-like sediment, they add yellow sulfur (which has been ground and sieved through a fabric). One adds the whole mixture to a stone pit and grinds it with a wooden pestle. After two hours, one adds the mixture to a container and places it in the shade for two days. After that period, one pounds the whole again

and adds some water so that it is sticky. Then one sieves the dough so that it turns into small grains. Then one places the grains in a piece of fabric and shakes them so that they turn into small grains the size of millet or even smaller (circa 1 millimeter). Then one places this mixture on a plate and places it in the sun (away from the wind and dust) and lets it dry. After this, the gunpowder is ready.[48]

3.4. Making naphtha

Chapter two of part nineteen of the treatise *Javāher al-Sanāye'* deals with *eskandari* oil (Greek fire) that is used in warfare.

Chapter two: About making eskandari oil

They take one part of each of the following items: Persian naphtha, sandarac [Tetraclinis articulata], calcined talc, reed oil, and one-tenth of mercury naphtha, and place them all in a thick stable container made of zinc which has a narrow throat. The cover of the container should also be made of zinc so that they fit tightly. They place the cover/lid tightly, and place it in a heated furnace for two days and nights. Then they take it out and make a jug of the same size as the container. Then they place the container in the jug and place fire under it for one day and night. Then they take it out and allow it to cool for one week. After one week, they open its lid and use it when needed as will be explained. If they throw two deram of this oil in the enemy's city or castle, it will be completely burned, and no matter what they try, they will not be able to extinguish the fire. The only way to extinguish it is to mix menstrual blood from female genitals with vinegar, rub it on stones, and throw them at the fire; this immediately puts it out.

Table 6

Ingredients for making naphta

Ingredients	Persian naphtha	Sandarac	Calcined talc	Reed oil	Mercury naphtha

Source: Author's own elaboration.

The text differentiates between Persian naphtha and mercury naphtha, but it does not provide any information on their respective ingredients or nature.

[48] M.M. Khorasani, *Persian...*, p. 43–44; B.A. Ahmaādiyān, *Pajuheši Dar Bāre-ye Il-e Baxtiyāri*, Tehrān 2008, pp. 121–122.

Fortunately, the text provides information on reed oil at the end of chapter two of part nineteen. It reads:

> A chapter about making reed oil, which is necessary for making eskandari oil, and for its usage. Its making is one of the secrets, but I have not kept it confidential. They take lots of fresh reeds, which are still fresh but yellowish. They cut them into pieces and place them in oil of black sesame [Sesamum indicum] so that they absorb and soak the oil. Then they put them in a glass and put refractory cement around the glass. Then they place in its throat [of the glass] hair from a horse's mane. Then they place it in a hole of dried brick so that the mouth of the glass [container] extends over the dried brick. They cover it in refractory cement and place the glass [container] upside down. They place a container below the mouth of the glass and place dried cow dung taken from the fields around the glass's mouth and place a fire around it. The oil starts to drop [into the container]. They collect it and boil it with the oils, which have been mentioned before, as great God willing.

Table 7

Ingredients for making reed oil

Ingredients for making reed oil inside the container	Fresh reed	Black sesame oil	Hair of horse mane
Ingredients outside the container	Dried cow dung		

Source: Author's own elaboration.

The third chapter of part nineteen describes how to make hollow grenades to be filled with naphtha and thrown by catapults at the enemy's fortifications, also noting that naphtha can be used to fill fire arrows to be shot at enemies. The text reads:

> The third chapter is about making the mentioned eskandari oil which puts fire in castles and cities. They bring iron and make hollow balls. Each ball has a capacity of two *deram* or even more. There should be a hole in each ball so that they can fill it with the mentioned oil. They place a fuse in it. The ball should be made in a way so that if they put it in a catapult and ignite its fuse and throw it at the enemy's cities, the fire reaches the cavity of the ball through the fuse and the moment the ball reaches the city, fire will engulf the whole castle, and the entire city will burn down completely. If they place this oil in the crevice of the air arrow [fire arrow], it can also set everything on fire, and it never cools unless they do what was mentioned before.

Then the text describes how to ignite a fuse or use a piece of cloth to ignite the naphtha. The text describes:

> Another method for making it is to burn cities and castles. They bring female hair and place it in a melon. They place dried straws below the melon and hold Syrian [magnifying] glass to shine on the straws. They also place pieces of rock crystal on the straws. Then they let the sun shine on them so that the straws catch fire. They put a cloth under them so that the side of the cloth catches fire.

The treatise *Javāher al-Sanāye'* also provides a recipe for making another type of explosive as follows: "Another type: They bring ground dried donkey dung and mix ground sandarac with it. They grind sulfur and add it to the mixture step by step. Then they throw it at the enemy's fortifications, which will catch fire immediately. This is also a tested method".

Table 8

Ingredients for making another type of explosive

Ingredients	Donkey dung	Ground sandarac	Sulfur

Source: Author's own elaboration.

4. Conclusion

As we have seen, the Persian manuscript *Javāher al-Sanāye'* جواهرالصنایع [*Jewels of Crafts*] deals with many different topics of changing the colours of different types of stones. The text describes one hundred and sixty crafts divided into forty parts. Each part consists of different chapters. The book is important for war-related research as it describes how the craftsmen made crucible steel and quenched blades. It also describes the process of making casein glue for attaching the blade tang to the handle and for using in the mixture of glue used for attaching feathers to arrow shafts. It also describes the formula for making naphtha and making grenades for holding naphtha. In earlier research, we were able to replicate the casein glue for attaching the blade tang to the sword handle. Future research should try to replicate the crucible steel process, quenching processes, the glue for attaching arrows, and also the formulas for making naphtha as described in the treatise. Old treatises on warfare, such as the present example, provide us with invaluable information on the material culture of the period and with a better understanding of historical artifacts such as swords and armour.

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KLEJNOTY RZEMIOSŁA: KUCIE OSTRZY, PRZYKLEJANIE LOTEK STRZAŁ, WYTWARZANIE NAFTY I CZARNEGO PROCHU – PERSKI MANUSKRYPT DOTYCZĄCY DZIAŁAŃ WOJENNYCH

Streszczenie. Niniejszy artykuł dotyczy niedatowanego perskiego manuskryptu zatytułowanego *Javāher al-Sanāye'* جواهرالصنایع [*Klejnoty rzemiosła*]. Wiele perskich rękopisów dostarcza bezcennych informacji na temat produkcji broni, kucia mieczy, technik łuczniczych, atakowania fortyfikacji, odlewania armat i wytwarzania broni palnej oraz strategii wojskowych. Większość relacji na temat wytwarzania stali tyglowej jest częścią traktatów dotyczących klejnotów i kamieni. W mojej ostatniej książce *Jewels and Patterned Crucible Steel: Books of Jewels, Stones, and Metals* przedstawiłem tłumaczenie i uwagi do traktatu *Goharnāmeh* [*Księga klejnotów*] napisanego przez Mohammada ben Mansura dla władcy Uzuna Hasana Āq Qoyonlu w XV w. n.e. (w dziewiątym wieku hidżry). *Goharnāmeh* opisuje kamienie szlachetne i półszlachetne, produkty pochodzenia zwierzęcego i metale. Zasadnicza część traktatu dotyczy ostrzy i wytwarzania stali tyglowej, jednak manuskrypt *Javāher al-Sanāye'* [*Klejnoty rzemiosła*], który jest tematem tego artykułu, dotyczy transformacji kamieni i metali. Rękopis opisuje, w jaki sposób rzemieślnicy wytwarzali stal tyglową i wyjaśnia, w jaki sposób hutnicy używali tygli do przeprowadzania innych procesów alchemicznych, między innymi do zmiany i przekształcania koloru kamieni. *Javāher al-Sanāye'* to klejnot sam w sobie, źródło informacji dla badaczy tematów związanych z wojną zawierający bezcenne informacje o tym, jak wytwarzać ostrza ze stali tyglowej, jak rozróżniać i klasyfikować miecze, jak wytwarzać klej do mocowania trzpienia ostrza do rękojeści, klej do mocowania lotek strzał, naftę (materiał zapalający) do atakowania fortyfikacji oraz czarny proch.

Słowa kluczowe: stal tyglowa, miecz, strzała, nafta, lakier do łuków, czarny proch, Persja, Iran, średniowiecze, dynastia