



Refrigeration Technology in Anatolian Seljuk and Ottoman Period Hospitals

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ABSTRACT

The precise identification of ancient refrigeration systems is problematic, since nearly every technological advance is the result of long accumulation of human experience shaped according to the environmental, cultural, social and climatic conditions of the period and region. Besides, the scarcity of firsthand documentary records doubles the problem. Therefore, in the course of the discussions, being aware of the difficulties of the subject matter, it was an important phase to fill the gap in the area of history of refrigeration technology by the help of the hospital cases in Anatolia. It takes the form of a case study that focuses as much on the context and motives for the possible refrigeration technologies used and applied in historical hospital buildings.

Key Words: *refrigeration; technology; architecture; historic hospital; Anatolia.*

1. INTRODUCTION

There are few studies conducted on the evolution of refrigeration systems of historical buildings throughout the world and of specific regions, especially Middle East. Nevertheless, those systems have not been sufficiently analyzed yet in terms of their relation with architecture, design principles and technological developments. Therefore, this article aims to portray various refrigeration principles involved and applied in the science of refrigeration throughout the world and to present the cases for original refrigeration systems among the thirteenth to seventeenth century Anatolian Seljuk and Ottoman period hospital cases, which are mostly or partly intact today, through extensive in-situ site work, literature survey, and archival studies.

2.2. HISTORY OF REFRIGERATION IN THE WORLD

In order to fully understand the development of refrigeration technology in hospital cases one must first look at the historical context of the subject matter. The term “*refrigeration*” is concerned with “cooling a body or substance by lowering the temperature of the body and by keeping its temperature below that of the surroundings at a particular time and place” [1-5]. It is not correct to search for the roots of history of refrigeration within the peripheries of a specific country or a region. For centuries, humankind have found and applied different refrigeration methods not only to preserve their foods but also for cooling their bodies, living spaces, and beverages. The conditions of weather, environment and nature in which the humankind lived, affected the techniques used to refrigerate the foods and their living

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spaces [6]. Primarily, humankind used the nature's refrigeration techniques. Refrigeration was achieved either by temperature differential or by evaporation or by the combination of them [4, 7].

2.1. Early Refrigeration Technologies

In the periods that artificial cooling was not known yet, main means of refrigeration were the ice transported from colder regions and snow carried from high mountains by animals or slaves and these ice and snow were kept in insulated spaces [3, 5]. Snow, ice, a cool river or water supply, caves, cellars, and icehouses were used for centuries to preserve foods from spoiling and to keep beverages and spaces cool. Chinese were thought to be the first to store natural ice and snow to cool wine and easily spoiled food. There are evidences on the existence of traces of icehouse in China even from 1000 B.C. During storage, it was paid great attention for not to be in direct contact of this stored snow and ice with the food and beverages, or else, the mix of impure materials in the process of crystallization of ice and snow might cause epidemics such as typhoid fever, dysentery and such [2, 6, 8-9]. Foods as meat and fish, which tend to spoil easily were generally preserved by salting, spicing, smoking, and drying [6]. In Europe, except from southern countries such as Italy and Spain, the process of cooling the liquids by using ice and snow was started to be used towards the end of the sixteenth century [6]. As for the use of potassium and sodium nitrate and snow, solution with salt to produce low temperature and ice was learnt as early as the fourth century by East Indians [8].

Another method of refrigeration was radiation. This method was common especially in India and Middle East. In this method, a thin layer of water was kept in shallow terracotta jars, sides of which was insulated with approximately 30 cm height of straw layer, thus ice was made during cold nights to be used during the day. It is not known exactly in which period this method was discovered. But, it is known that, around fourth and fifth century B.C., Egyptians exposed the water to sunrays during the day time and at night and they obtained cold water by skimming the thick piece rising to the surface on the water and by keeping the rest of the water in porous clay jars [3-4, 7, 8-9]. The water inside the terracotta jars lost heat by means of radiation and turned into ice. In Egypt, a similar method was used to produce ice. Terracotta jars filled with hot water and put on the flat roofs of houses exposed to the air stream during the night [6, 9]. Slaves were used to moisturize the jars from outside, thus the resulting evaporation caused the cooling of water [9]. The Ancient Greeks and Romans used underground pits to store ice and insulated the environs of these pits with straw, hay, grass and such, thus provided storage of foods without spoiling for long periods. In order to cool the beverages, they added snow directly into their beverages. It is also known that during the period of Roman Emperor Nero, liquids within the jars were buried into snow [6]. In addition, there were cellars and icehouses constructed to store ice in Europe, Iran, Anatolia, and the U.S.A. Interiors of these spaces were covered with straw or sawdust for the insulation purpose thus the melting of ice was tried to be prevented. Nevertheless, because of their poor quality of insulating

features, the walls of icehouses were constructed not less than one m thick [3].

Another natural refrigeration technique used in the history was the evaporation of the volatile liquid. In this method, the heat loss was provided by the help of the evaporation of liquids exposed directly or indirectly to the warmer substances from which they absorb heat. For centuries, to provide cold-water especially in hot weathers and hot regions, water was kept in terracotta jars. Water inside the terracotta jars evaporated to the periphery from the pores of the jars and thus heat was absorbed during the evaporation process and carried away by the resultant vapour and cooling was substantiated [4].

2.2. 18th – 19th Century Refrigeration Technology

Artificial refrigeration was discovered for the first time by William Cullen in 1748. Cullen achieved to produce ice by using a pump located on a diethyl container thus providing the absorption of liquids reached to boiling with evaporation temperature and cooled its periphery [9]. Developments in transfer and storage of ice and snow also affected the development of artificial refrigeration systems. Insulated boxes, called iceboxes, above which the ice and below the food were located, were invented and started to be used in 1823. Jacob Perkins developed the closed refrigerator to provide cooling by using the expansion and compression systems of liquids [2]. At the beginning of 20th century, it was a prevalent method in refrigeration technology to keep the natural ice cut from the rivers and lakes in icehouses and to distribute it to dwellings and working areas [10].

2.3. Examples From Anatolia and Middle East

As for Anatolia, İmamoğlu states that snow stored in cold winter months in wells and caves, in Kayseri, were used in hot summer days for cooling purposes. He also states that meat, vegetable, and fruits were stored in the underground pits for refrigeration [11]. It is also known that in summer days, ice and snow were cut by using saws in pieces from the Mount Erciyes (the nearest volcanic formation) and sold on wooden stalls covered with wet cloths in the streets. These ice and snow pieces were used in houses for cooling and kept inside the primitive iceboxes [11]. İmamoğlu further informs that in historical Gesi houses of Kayseri, grain were kept in big wooden boxes and the legume, walnut, almond and other dried vegetables and fruits were kept in the cool cellars, depots and storehouses [12]. In order to preserve pickled and canned vegetable, fruit, and cheese, terracotta pots and jars were used and kept in cellars. Cellars, depots and storehouses were generally set up by digging in the smooth rocks under the ground floor level of the houses with small crenel windows and their floor surfaces were covered with 5-6 cm thick earth or mat. In these spaces, terracotta jars with cheese were buried underneath the ground and vegetables and fruits were laid on earth or mat [12]. Besides, the chimneys located as the extension of fireplaces inside the rooms and lying through the roof helped the rising of hot weather and displacing with cold weather, thus providing the cooling of the space.

Another traditional structure mostly constructed with mud, mud brick, brick or wood and used for refrigeration and ventilation, especially in Iran is called “badgir” or weathering shaft/ventilation shaft/wind-tower/wind-catcher. In this system, the hot fresh air captured from outside at the top of the structure, passes through a simple canal and delivers the cooler air at the bottom of the canal connected with a water pool at the basement [13-15]. In the same way the polluted, hot air is sent to outside. These basements are preferred to be used for cooling in hot summer days by the inhabitants. In addition, the basements are generally used as natural refrigerators to store food and liquids. The tallest badgir in the world is built in the courtyard of Dowlat-Abad in Yazd, Iran with 33 m height [13-15]. In Yazd, most of the mosques, water reservoirs and residential buildings have badgirs in their basements. In order to cool the water in water reservoirs the badgirs are generally located unidirectional or bilateral facing the appropriate wind. Wind entering from one side of it goes out from the other side after it hits the water in the reservoir. Sometimes badgirs are separated from the building and connected with the room via an

underground tunnel thus; air is kept cool before entering the room [15].

Another refrigeration system called as “cold weather storage window” was observed in Sana, Yemen during a technical visit to the House of Imam Yahya in 2010 (Figure 1). In this system, the window projects half to one meter outwards on the façade with small holes on the front and reciprocal sides of the projection to permit the airstream enter from one side and to leave from the other side. Consequently, an air pressure is produced inside the window resulting in cooling of the foods put on the window base even up to three days in hot summer months. The inner side of the window is closed with a wooden shutter.

A similar system is observed in the crypt section of the tombs and basement floors of the houses in hot climate regions of Turkey. As a result, by the help of the location of windows reciprocally, an airstream is provided inside the crypt section and thus cooling of the space is achieved.



Figure 1. Interior view of a cold weather storage window (left) and exterior view of another cold weather storage window (right) in the House of Imam Yahya, Sana, Yemen [16]

Another ancient natural refrigeration system used to store and cool ice and food is the ice-chamber which is also called as “Yakh-Chal” and observed in Iran. Ice-chambers generally connected with qanat or badgir on one side are mostly huge structures up to 5000 m³. They are constructed with heat resistant materials with thick

walls no less than two meters [17]. Building construction materials, plan layouts and directions of buildings, and wind are the other factors affecting the cooling of historical buildings. Possible refrigeration systems/elements/means applied in the history are given in Figure 2.

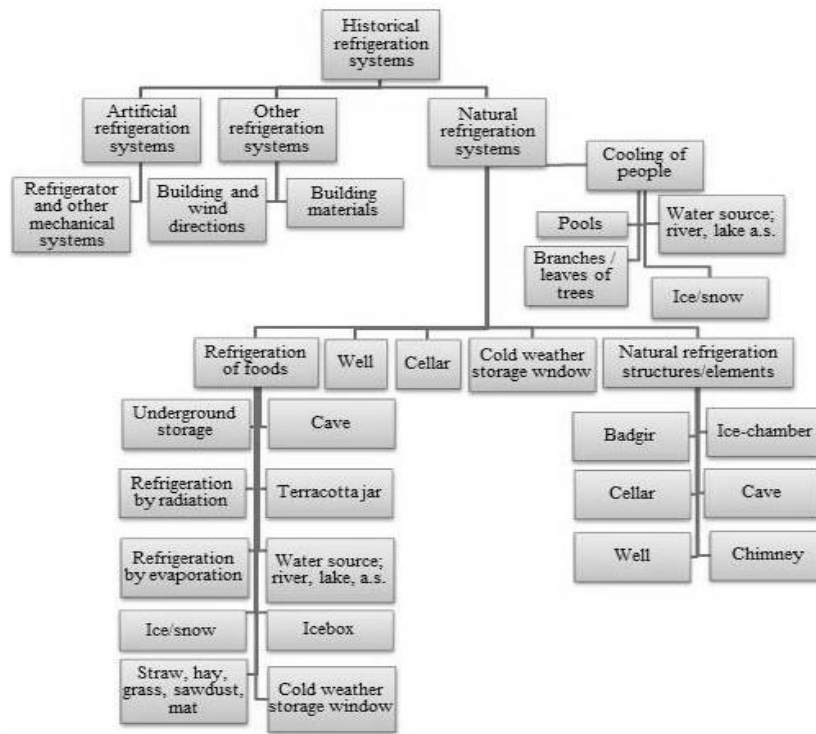


Figure 2. Refrigeration systems used in the history

3. REFRIGERATION SYSTEMS IN ANATOLIAN SELJUK AND OTTOMAN PERIOD HOSPITALS

In this part of the study, history of refrigeration in Anatolian Seljuk and Ottoman period hospitals are identified in the light of the archival documents, in-situ observations and above mentioned historical refrigeration methods. In order to be able to cool the patients with fewer and to cool the living and service units of hospitals, as well as to refrigerate foods and liquids, in Anatolian Seljuk and Ottoman Period hospitals similar methods were used as in the history. Among the natural refrigerants, ice and snow were the mostly used cooling substances to prevent spoiling of syrup, paste, oil and such kind of medicine and of foods prepared according to the descriptions of the doctors for the in-patients.

The wells in the courtyards of hospitals were also thought to be used not only to provide water but also to store snow in cold winter times to be used for the cooling of water and foods in hot summer days. During the in-situ site work, in total four hospitals, namely, Süleymaniye, Edirne II. Bayezid, Haseki and Atik Valide Hospitals, in the courtyards wells were observed (Figure 3 and Figure 4). In Divriği Melike Turan Hospital the existence of wells was known from the archival records. It was also possible to buy snow when the need arose. There are waqf records concerning buying of snow especially for the mosques and fountains during summer months. For instance, in a waqf deed belonging to Ahmet Ağa, brother of Hacı Hasan Ağa dated June 1758; it was written that every year certain amounts of snow would be bought from the incomes of that waqf to be used in mosques and fountains in hot summer days for the requiems of his mother and wives [18]. Considering its common

application in Anatolia, similarly in historical hospitals, easily spoiled foods such as meat and fish is thought to be stored by salting and drying.



Figure 3. A view from the well in the courtyard of Süleymaniye Hospital [16]



Figure 4. A view from the well in the courtyard of Atik Valide Sultan Hospital [16]

Among the historical refrigeration systems, badgirs and cold weather storage windows have not been met in the Anatolian Seljuk and Ottoman period hospitals. Cellars as a part of the hospitals were the most common refrigeration /cooling /storage spaces used for the storage purposes of medicine, grain, foods, and etc. Ice and snow were also thought to be used for the preservation of foods and medicines either to be stored in iceboxes, icehouses or wells in the courtyards of the hospitals.

When the waqf deeds and other archival documents of Anatolian Seljuk and Ottoman period hospitals are examined and through the in-situ observations, it is understood that in total six hospitals there are cellars for storage of foods and medicines. For instance, in the waqf deed of Sivas I. İzzettin Keykavus Hospital dated March 1218, it was written that; “every year one thousand mud (a metric unit) of grain would be used and the rest of it would be preserved in the cellar of the hospital” [19-20]. From this remark it is understood that the hospital had a cellar for the storage of grains. In addition, in the same waqf deed, an icehouse known as “the icehouse of Kayserili Reisü'd-din Alişer b. Hasan” was counted among the belongings of the waqf [21]. Unfortunately, the specific features of the icehouse are not explained in this document. Moreover, from that document it is understood that in that period there were certain structures of icehouses serving for the preservation of foods and liquids of waqf buildings. No room has been come across to be the icehouse inside the hospital during in-situ observations. Nevertheless, since the existence of icehouses is known to be used in Anatolia for storage of ice, it can be estimated that ice necessary for the hospitals could also be provided from a nearby icehouse. If existing, a nearby cave was also used to store and preserve the foods and liquids in the past. In consideration of the proximity of a nearby cave, among the Anatolian Seljuk hospitals, in Anber bin Abdullah Hospital, the use of such a cave for the storage purpose can be mentioned. Also, since it is known that in Kayseri, storage of ice and snow in caves was a common method of refrigeration, it is thought that, in Kayseri- Gevher Nesibe Hospital such storage might have also been used.

In historical hospitals, also artificial refrigeration methods were used not only to preserve food, liquids, and medicine but also to cool the weather of the patients' rooms for the sick with fever [9]. Nevertheless, it was not until 1845 that Dr. Gorrie(1803-1855), who used the method of rapid expansion of gases for cooling of substances and was granted the first U.S. patent for mechanical refrigeration, achieved to make artificial ice to cool the air in hospitals where there were patients with fever cases [22]. First, fever was tried to be controlled by cooling the patients by external means. Then, later Dr Gorrie produced small blocks of ice in the size of ordinary building brick, thus being the precursor for the compressed-air ice-making machine [23].

It is not known whether there was a cold mortuary in historical hospitals of Anatolia for the death incidences. However, from the records it was understood that the dead were buried as soon as possible after their funeral prayer without necessitating a mortuary to protect the

health of surviving sick people in the hospital [24]. Besides, in waqf deeds among the people on duty in hospitals, imam and muezzin were also counted. Most of the hospitals either have their own masjids as a part of the functional units in the hospital or were the parts of a külliye (mosque complex) already having a huge mosque in it. Hence, it is assumed that the imam and muezzin were responsible not only for the pray during the time of prayers in a day, but also for the funeral prayer of the dead in the masjid of hospital or in a nearby mosque. For instance in a register belonging to Bursa Yıldırım Hospital dated to 21 June 1523, it was written that two akçe/coin should be given to imam for the funeral prayer of the dead in the hospital [24]. In addition, use of thick stone walls as the construction technique and material preference given to the airy regions for the location selection of hospitals, pools generally located at the centre of the courtyards, open-courtyard plan layout and semi-open spaces designed within the hospitals were the other factors affecting the refrigeration and cooling quality of the spaces in Anatolian Seljuk and Ottoman period hospitals.

As for the assessment of the technological developments in historical hospitals; it can be concluded that in both Anatolian Seljuk and Ottoman periods, cellars were used in both periods for the preservation and storage of foods and medicine. Wells and pools were the other common refrigeration and cooling means. Climate and environmental conditions also affected the type of refrigeration, but there is not a considerable development difference between the two periods, the only one being the chimney additions in the rooms of hospitals in Ottoman period instead of holes above ceilings in Seljuk period hospitals. Possible refrigeration technologies used in Anatolian Seljuk and Ottoman period hospitals are sorted according to their reconstitution information sources and are given in Table 1.

Among all the refrigeration systems/elements/means observed in Anatolian Seljuk and Ottoman period hospitals it is seen that 29% of them could be detected exactly because of the existence in the building, such as pools, wells, and chimneys. Among the other refrigeration technologies 5.5% could be identified from the other examples of the mosque complex, 25.5% could be determined from the written or oral sources, and 40% could be identified from the historic and local refrigeration/cooling means observed in the region.

Table1. Table showing the refrigeration systems/means/elements in Anatolian Seljuk and Ottoman period hospital

Name of the Hospital	Built Year	Refrigeration/cooling of the space, body and the food																								
		Pools				Cellar				Well				Chimney				Nearby Cave		Ice/snow						
		■	▨	▩	▪	■	▨	▩	▪	■	▨	▩	▪	■	▨	▩	▪	■	▨	■	▨					
Gevher Nesibe Hospital&Medicine Madrasah	1205	■				■								■						■						
I. İzzeddin Keykavus Hospital	1217	■				■								■							■					
Divriği Melike Turan Hospital	1228	■											■								■					
Anber Bin Abdullah Hospital	1222-32		■				■											■			■					
Bursa Yıldırım Bayezid Hospital	1400	■				■							■	■							■					
Fatih Hospital	1470		■			■							■	■							■					
Edirne II. Bayezid Hospital	1484	■				■							■	■							■					
Hafsa Sultan Hospital	1539	■				■							■	■							■					
Haseki Sultan Hospital	1550					■				■											■					
Süleymaniye Hospital	1559	■				■							■								■					
Atik Valide Hospital	1582					■							■								■					
Sultan I. Ahmed Hospital	1617		■				■						■								■					
Subtotal		7	0	3	0	0	0	0	0	9	2	4	0	2	6	5	3	0	0	0	0	2	0	0	0	12
Total		10				11				12				8				2		12						

Reconstitution Information Sources

▨ The ones known exactly because of its existence in the building

▩ The ones having no traces in the buildings but the existence and traces could be identified from the other examples of the mosque complex

▪ The ones having no traces in the buildings but the existence could be identified from the written, oral or visual sources

▫ The ones having no traces but the existence and traces could be identified from the historic and local service systems observed in the region

4. CONCLUSION

Up to the end of the nineteenth century with the developments in refrigeration and transportation technologies, in rural settlements and even in city centres living conditions were quite hard when compared to today's conditions. Hence, up to that period, most of the buildings including hospitals in Anatolia lack the advanced service systems as in the case of refrigeration systems. The technology of the time, the scarce sources, climate and the environmental conditions of the region were the deterministic factors for the comfort understanding of the people in terms of refrigeration systems. Therefore, they had to present much effort, power and sacrifices to be able to refrigerate their foods and spaces and to cool their bodies when compared to current conditions. Considering death events, no traces were found proving the existence of mortuary places in hospitals. As for the refrigeration of spaces it can be concluded that chimneys of the fireplaces, cellars, and wells were the main refrigeration elements and spaces in historical hospitals; and pools, ice, and snow for the cooling of the body. Thus, considering all above mentioned refrigeration methods used and applied in Anatolian historic hospital cases, this manuscript also shows how successful and sustainable those methods were despite the hard conditions and scarce resources of the period.

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CONFLICT OF INTEREST

No conflict of interest was declared by the authors.

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