Information Horizons: AMERICAN Journal of Library And Information Science Innovation
Volume 3, Issue 3, 2025 ISSN (E): 2993-2777

Changes in Water Properties During the Cocoon Winding Process

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Abstract. *In the cocoon processing process, heating the water has a significant effect on the alkalinity, despite the dissolved substance from the cocoon casing and silkworm pupa in the cooking bath. This is because a significant portion of the alkali metal salts contained in the cocoon casing are dissolved during immersion in those stages of processing that occur at low temperatures, and the alkalinity in the working bath tends to increase. Since a large amount of water is added in the final section at low temperatures, the properties of the water in this part of the processing approach those of the original water. If water containing a high degree of alkalinity is used in the conditioning section, there is a risk of increasing the pH to very high levels.*

It is preferable to keep the alkalinity low by maintaining a high temperature in this section. The water used in the decoiling operations is at a lower temperature and is therefore affected by the properties of the original water. The quality of the decoiling water is of great importance compared to the cooking process. Very little soluble matter from the cocoon shell is present in the decoiling bath, since most of it has already been dissolved in the cooking process, but there will be some soluble matter from the pupae that has not been dissolved in the cooking bath.

Keywords: *cocoon, softening, swelling, sericin, alkalinity, acidity, silk, hardness, steaming, dissolution.*

Introductions. Water is used in industry for many purposes. The main ones are: the use of water for its physical and chemical properties, the use of water for energy production, and the use of chemical compounds in solution. In silk-reeling operations, water is used for its physical and chemical properties and chemical compounds in solution. The silk cocoon consists of a cocoon thread glued with sericin. The silk-reeling process is a wet process, where the cocoon thread is wound layer by layer. This operation is facilitated by softening and partially dissolving the sericin layer around the thread by heat and water treatment, causing the sericin gel to swell, which is glued to the cocoon thread.

The water used in the degumming bath not only penetrates the cocoon and controls the level of the cocoon's floating and sinking in the bath, but also helps soften the sericin, swell it, and separate it from the other layers of thread that form the cocoon.

The softening and swelling of the cocoon thread, which facilitates the unhindered unravelling of the thread from the cocoon, is related to temperature, pressure, as well as pH and chemicals in the solution.

However, water for cocooning cannot be treated in the same way as water for other types of production. Water undergoes many changes during the various heat treatments of cocoons. In most other productions, the quality of the water used has a direct bearing on the quality of the final product. There is no point in assessing the properties of water for cocooning without taking into account the many changes in this process. The properties of water in different working baths differ significantly from each other depending on the changes in the treatments that the cocoon undergoes [1-4].

The results obtained and their analysis. Constant changes occur as a result of heating and dissolving the substance from the cocoons. Changes that occur as a result of heat treatment. It is necessary to understand the nature of the changes that occur with the various components that dissolve in water, as well as with the concentration of substances dissolved in water.

The combination of different cooking methods, the properties of the water and the different concentrations of silk thread substances in the solution make it possible to vary the quality of the water for cocoon reeling. The changes in the properties of the water depend on two main factors. One is the change caused by heating the initial water and the other is the change that occurs as a result of the dissolution of various substances from the cocoons during the cooking process. More changes occur in the first stage of the operations than in the second [4-5].

Investigation of the pH changes during the different stages of cocoon cooking shows that the water is reduced to near neutral by the alkaline salts that dissolve from the cocoon shell even when soft water, which is generally acidic, is used in the dipping stage. The water in the dipping operation typically has a high pH if the pH of the original water is also high. However, the degree of change in the dipping operation is much less than that of the original water. The changes that occur during the infiltration of water into the cocoon are approximately the same in the infiltration operation as in the dipping stage. However, there are some differences. The water in the low temperature stage is less affected by the solutes from the cocoon shell and pupae, whereas their influence is more pronounced in the dipping stage. The pH generally rises during boiling and conditioning due to the alkaline solutes dissolving at high temperature. The pH of the water in the finishing section decreases due to the acidic solutes from the pupae. Conductivity denotes the total amount of ionized solute. The fact that the electrolytes in the cocoon shell and silkworm shell are easily dissolved even at low temperatures, most of them are dissolved in the initial stages at high temperatures. This leads to the creation of a higher concentration of components that enhance conductivity when in the solution of the cooking bath.

On the other hand, the electrolytes contained in the pupa and acidic in nature dissolve in the cocooning bath.

From the relationship between conductivity and initial water, it can be concluded that changes in heating are the cause of low conductivity in water with a high level of temporary hardness. The degree of conductivity of water in the bath for cooking is low.

There are cases where the properties of water reduce the hardness of the water in the bath for cooking. The more substances are dissolved in the bath, the stronger the hardness. Changes in the hardness of the water for cooking are the same as changes in conductivity, since the components that affect these changes are electrolytes.

The hardness component dissolved from the cocoon shell is present to a greater extent in the inner layer than in the middle outer layer. Under high temperature conditions, the hardness components in the outer layer dissolve easily. Or if the temperature is low, only a small amount of the components dissolve. The inner layer will dissolve partially. The compounds causing water hardness dissolve much faster than sericin during prolonged treatment even at low temperatures.

With an increase in the number of components that increase the hardness of water in the bath for cooking can be reduced and excess sericin dissolution can be controlled. This ability to control solubility is of particular benefit when using hard water.

Changes acidity and alkalinity of the original water could occur during heating and depend on the type of electrolytes present. Heating significantly affects the alkalinity, despite the substance dissolved in the cooking bath from the cocoon shell and silkworm shell (1-table).

Table 1. Presence of alkalinity and other components in the cooking bath

Cooking processes	Alkalinity			Acidity			General hardness		
	limits	average	number of factories	limits	average	number of factories	limits	average	number of factories
Properties of water	0.63	25	15	3-66	21	16	1.0-5.0	2.8	10
Immersion	3-131	72	15	3-44	22	16	1.5-9.3	4.4	9
Low t^0	2-145	59	15	3-62	26	14	1.8-7.6	4.3	9
Air conditioning at high t^0	32-77	52	7	3-30	14	8	3.0-4.6	3.8	4
Air conditioning at low t^0	30-61	49	8	3-28	13	9	2.0-3.3	2.9	5

Therefore, regardless of the substance dissolved in the cooking bath from the cocoon shell, a decrease in alkalinity is observed when the water is heated to a high temperature. The dissolved substance has a significant effect on the change in acidity than on alkalinity.

This is due to the fact that a significant portion of the alkali metal salts contained in the cocoon shell dissolve during immersion at those stages of processing that occur at low temperatures, and the alkalinity in the working bath tends to increase (Table 2).

Table 2. Properties of water in different areas of the cooking bath

Properties of water	**pH**	**Conductivity (m2 / cm)**	**Total alkalinity mg/l**	**Total acidity mg/l**	**Total hardness mg/l**	**Total amount of evaporation sediment and mg/l**	**Total Solids/Conductivity**	**Appearance of the solution**
Initial	7.5	295	36	4.8	5.8	241	0.82	Colorless and pure
Infiltration	7.6	362	59	8.5	5.9	356	0.98	Slightly cloudy yellowish
Cooking	7.6	700	63	22.5	10.3	1415	2.02	Yellow and slightly cloudy
Conditioning at high t^0	8.0	300	28	4.5	5.0	424	1.41	Yellowish and slightly cloudy
Conditioning at low t^0	8.0	291	27	4.5	4.9	403	1.39	Yellowish and slightly cloudy

Despite the use of low temperature and low solubility of the cocoon layer, high concentrations of alkalinity and acidity are recorded in the immersion and infiltration stages. The reason is that very little water is added in these stages compared to the amount of water added in other stages of processing, therefore, the concentration increases in these stages.

Typically, the water in the conditioning stage (i.e., in the conditioning section) of a modern cooking machine, which has an acidity-reducing mechanism, does not increase acidity proportionally to the concentration of soluble matter, although soluble protein from the pupae is present in it.

Since a large amount of water is added in the final section at low temperature, the properties of the water in this part of the treatment approach those of the original water (Table 3).

Table 3. With the properties of water in the sections of the bath for cooking

Properties of water	**Initial water**				**Improved water (soft water)**						
	pH	Alkalinity (mg/l)	Acidity (mg/l)	Hardness (mg/l)	pH	Conductivity (mg/l)	Alkalinity (mg/l)	Acidity (mg/l)	Hardness (mg/l)	Total solids	Total solids/conductivity
Primordial water	--	133	2.4	6.2	-	330	136	3.0	3.9	--	--
Infiltration	7.6	131	4.6	8.9	7.5	525	145	5.8	4.6	564	1.07
Cooking	7.4	222	4.2	7.1	8.5	640	128	4.4	5.4	1014	1.58
Eruption	7.0	390	16.2	13.0	7.5	575	150	14.5	5.1	872	1.52
Air conditioning at high t^0	8.2	138	1.8	5.6	8.7	500	136	2.6	4.4	696	1.39
Finishing	7.3	153	2.8	6.5	7.7	410	158	3.5	3.3	260	0.63

If the conditioning section uses water containing a high degree of alkalinity, there is a risk of increasing the pH to very high levels . It is preferable to maintain a low level of alkalinity by maintaining a high temperature in this section. The brewing machine, which is widely used today, is not very suitable for using natural or acidic soft water, because when using this type of water, the pH of the water in the sections where the low temperature is used decreases more than in other sections.

As stated earlier, the properties of the original water have a significant impact in the finishing section, the final part.

Changes in water in steam baths with brushes and for selection were investigated (table 4).

Table 4. Water properties and concentration in steam baths with brushes

Properties of bath water	Maximum concentration	Minimum concentration
pH	6.8	7.8
Conductivity	500	220
Total acidity	30	3
Total residue after evaporation	1163	268
Crude protein	786	252
Protein from pupae dissolved in 50% alcohol solution	219	180

Since the water temperature in these baths rises to 70 ^{0} C and above and the water is alkaline, one would expect a significant increase in pH. However, in practice this does not happen, since the pH value is controlled by the buffering action. Caused by dissolved substances, mainly from the pupae. Therefore, the solubility of sericin above the required limit is controlled.

Table 5 shows the results of the analysis of water from the sampling bath. The water has two concentrations, one high and one low. This indicates that the higher concentration controls the solubility of sericin even if the original water, which is characterized by solubility, is used. The concentration of soluble substances, more than the properties of the original water, has a greater effect on the state of water in the brush steaming bath and the sampling bath. Generally, the concentration in the sampling bath is lower.

Table 5. The relationship between the selection bath and the steam bath

Baths	pH	Alkalinity	Total acidity	General hardness
Selection bath	6.9-8.2 7.4(18)	49-150 76(16)	5-40 21(14)	2.8-6.5 4.3 (13)
Steam bath	6.8-7.6 7.2 (18)	37-140 71 (14)	5-38 20 (12)	1.6-6.5 4.0 (13)

The water in the brush steam bath requires a higher level of buffering action, and the properties of the water are stabilized by the concentration of the solute compared to the original water, which has a higher level of buffering action.

However, the wate r used in decoiling operations is at a lower temperature and is therefore affected by the properties of the original water. The quality of decoiling water is of great importance compared to the cooking process (Table 6).

Table 6. Properties of water in the unwinding bath

Properties of water	pH	Alkalinity (mg/l)	Total acidity (mg/l)	Total hardness (mg/l)
Unwinding	6.6-8.4(7.1)	30-158(76)	6-35 (21)	1.8-6.7 (3.8)

There is very little soluble matter from the cocoon shell present in the unwinding bath, as most of it has already dissolved during the cooking process, but there will be some soluble matter from the pupae that has not dissolved in the cooking bath. These are continually dissolved in the unwinding bath, and therefore it can be said that the unwinding bath contains matter from the pupae. Although the bath solubles affect the same type of changes in the cooking and unwinding baths, they have little effect on the unwinding bath water in relation to the unwinding operation. Recommendations are only given regarding the differences between the cooking and unwinding water.

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