APPLICATION OF DEACIDIFICATION FOR ARCHIVES CONSERVATION AT THE SINGOSARI NATIONAL ARTIFICIAL INSEMINATION CENTER (BALAI BESAR INSEMINASI BUATAN, BBIB), INDONESIA

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1. Introduction

Archives are generally printed on paper. The paper constituting the archives can be affected by internal and external factors and over a long period of time, can easily decay and yellow stain spots can appear. Factors such as temperature, humidity, and the acidity level of the paper, will influence the physical strength of the paper. In order to save the valuable information in the archives, it is therefore essential to take action to preserve the physical paper. One of the internal factors that can cause deterioration and decoloration, especially for paper, is the acidity generated during its natural ageing.

Paper is a material containing several substances such as cellulose. Most paper is made of wood pulp. Cellulose is a linear polymer formed of repeating glucose molecules. Cellulose molecules in the wood pulp form strong hydrogen bonds with each other, as the water is drained and evaporated from the newly made paper [1]. The structure of cellulose is shown in Figure 1. Paper has a fairly random network consisting mostly of cellulose fibers, and very small amounts of lignin and hemicelluloses. The structure of the network and the length of the fibers determine the physical and mechanical properties of the paper. The strength of the paper depends on the quality of the cellulose fibers used [2].

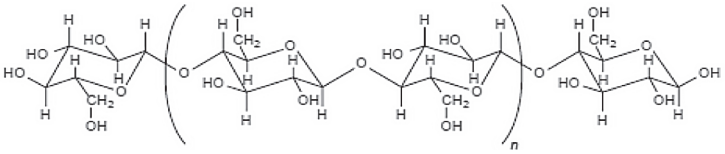

Figure 1. Cellulose

The chemical reaction that occurs during the aging of the paper is acid catalyzed hydrolysis of cellulose. The hydrolysis process lowers the degree of polymerization; consequently, there is a loss in paper strength and further hydrolysis will result in embrittelement. The reaction of acid catalyzed hydrolysis of cellulose is shown in Figure 2 [3].

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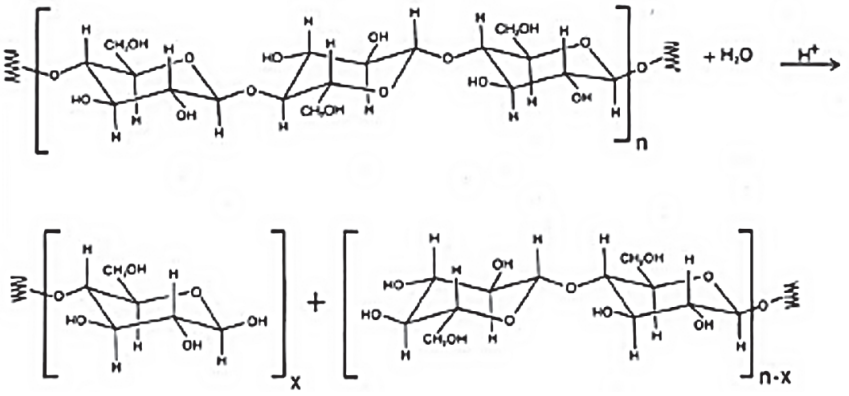


Figure 2. Acid catalyzed hydrolysis of cellulose.

The external factors that cause deterioration of paper consist of poor handling and storage, fire and flood, pests, pollution, light, incorrect temperature and relative humidity [4]. Physical factors are usually caused by environmental conditions. Temperature and relative humidity should be controlled to preserve paper because a high level of both temperature and relative humidity can significantly damage collections. Relative humidity (RH) is the ratio of water vapour pressure to saturation water vapour pressure (over water) at gas temperature [5]. High relative humidity can lead to harmful chemical reactions in materials. If it is combined with a high temperature, it encourages mold growth and insect activity. Extremely low relative humidity can occur in very dry climates and may lead to desiccation and brittleness of the paper [4].

Archival paper is a type of paper that has high permanence and durability, so it has the ability to retain its chemical and physical properties for long periods of time in a controlled environment. The paper included in the archive classification of paper should meet the parameters tested. The average pH of paper is in the range of 7.5-10.0 when using the cold extraction method according to ISO 6588 and the pH of the paper surface is greater than 7.5 [6].

Deacidification is a process that neutralizes the high acidity in paper. It is done by adding buffer solution to maintain the proper acidity of the paper [7]. Deacidification can be used to neutralize acid content in paper surfaces. Alkaline reagents that are suitable for deacidification include water soluble inorganic compounds such as calcium, sodium and magnesium. Applying an alkaline solution is effective in treatIng yellowing paper [8].

2. Method

This experiment was carried out in the old record center of Singosari National Artificial Insemination Center which has about 2500 original copies in their archives. These archives include the artificial insemination reports of Malang city, East Java, so they are important for reference purposes. The archives were created between 1980-2000. Around 40% of the archives in BBIB Singosari are damaged due to the process of aging and inappropriate storage conditions.

The experimental method employed is shown in Table 1.

Table 1. Experimental method

METHOD	ANNOTATION
Measurement of Temperature and Humidity	The measurement of the temperature and humidity of the storage room was taken using a digital thermo-hygrometer. Measurements were done three times: in the morning, day-time and afternoon for 30 minutes to get valid results.
Selection of Paper	Selection of the paper for deacidification was based on the value of the information (subject content), the year of creation (from 1980-2000), the chosen condition of the paper was its colour: brown or yellow, and the selected paper type was thin light-weight paper (e.g. carbon paper), scribbling paper and HVS paper.
Apparatus and Materials for Initial pH Measurement	Apparatus: Gloves, ruler, Mylar plastic, pipette, glass beaker, pencil, scissors. Materials: Demineralized water "*Hydrobatt"*, Universal pH "*MColorpHast Merck"*, Blue Litmus "*Macherey-Nagel"*.
Initial pH measurement	To measure the degree of acidity (pH) on the archive paper before the deacidification process
Deacidification process	Two techniques were used: brushing and spraying. Reagents: calcium carbonate ($CaCO_3$) and sodium carbonate (Na_2CO_3) solution of 0.1% and 1%.
Deacidification Apparatus and Materials	Apparatus: Gloves, Mylar plastic, glass beaker, dark glass bottle, scissors, spray bottle, brush, ruler, pipette, pencil, stirring bar, measuring cylinder Materials: Demineralized water "*Hydrobatt"*, Universal pH "*MColorpHast Merck"*, Blue Litmus "*Macherey-Nagel"*, $CaCO_3$ and Na_2CO_3 solution of 0.1% and 1%.
Brushing Technique	A flat brush was used to apply the solution on the archive paper.
Spraying Technique	A gun sprayer (150ml) was used to apply the solution on the archive paper.
Final pH Measurement	After the deacidification process was completed, the pH was measured.

3. Result

3.1. Temperature and Humidity in the Singosari National Artificial Insemination Center

Temperature and humidity were measured to better understand the microclimatic conditions in the record center room. From the results shown in Figure 3 and Figure 4, the average temperature is 23ºC and the relative humidity is 79% (RH). That means that there is a high level of humidity in the storage room. As a result, fungus grows in the archives.

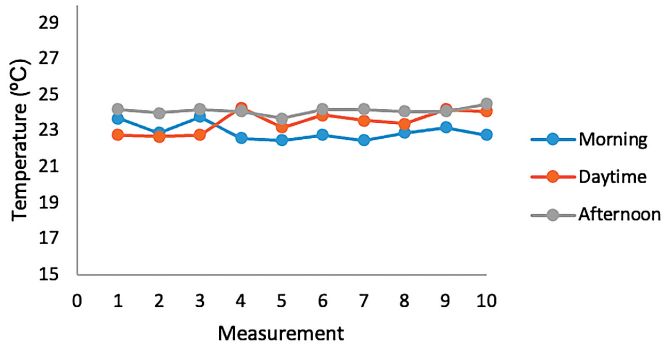


Figure 3. Temperature measurement.

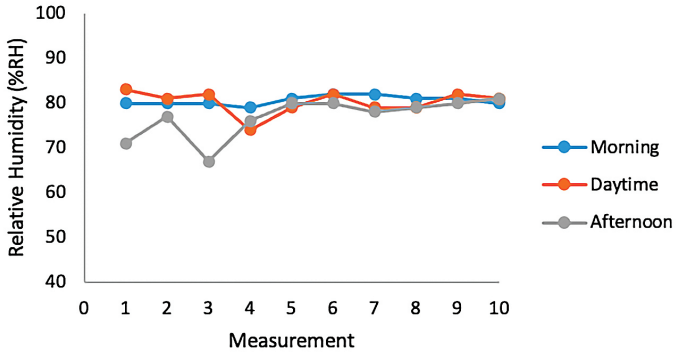
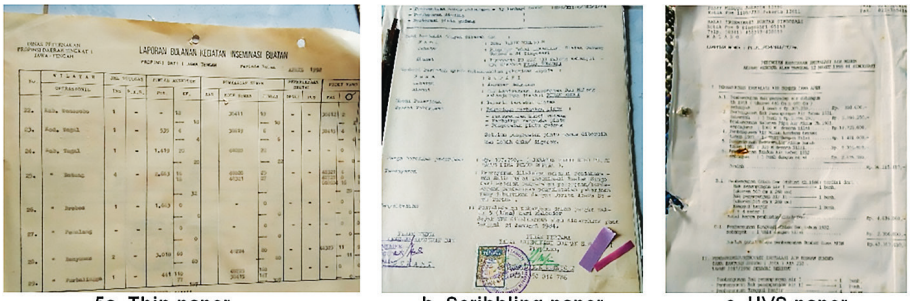


Figure 4. Relative Humidity measurement.

3.2. Deacidification

Deacidification was carried out on the three types of achive paper shown in Figure 5. Figure 5a is thin paper (carbon paper) which has turned yellow, 5b is scribbling paper which has turned brown or yellow and is moldy and damp, and 5c is HVS (wood-free) paper which is less yellow than the other papers. Before applying the deacidification reagent, the initial pH was measured to ensure the acidity condition of the sample paper, and this was done using blue litmus and universal pH.



5a. Thin paper b. Scribbling paper c. HVS paper

Figure 5. Different types of archive paper.

3.3. Initial pH measurement

The results of the initial pH measurement of the archive papers are shown in Table 2. The majority of archive papers have a low pH, which means they have a high acidity level. Among the sampled papers, there is one archive paper that gives a level of pH 7. It means the condition of the paper is neutral. This neutral pH condition is also proved by the litmus measurement. If the blue litmus turns red, it means that the paper has an acid condition.

Table 2. Results of the initial pH reading

No	Storage	Type of Paper	Color	Initial pH	
				Universal pH	Blue Litmus
1	Ordner (1992)	Thin paper	Yellow	6	Red
		HVS paper	Ivory	5	Red
2	Box (1998)	HVS paper	White	7	Blue
		Thin paper	Yellowish white	5	Red
3	Bundled archives (1984)	Scribbing paper	Yellowish white	6	Red
		Thin paper	Yellowish white	5	Red
4	Humid Odner (1985)	Scribbing paper	Yellow with fungus spot	5	Red
5	Box (1987)	Thin paper	White	5	Red
		Scribbing paper	Yellowish white	5	Red
		HVS paper	Yellowish white	5	Red

3.4. Deacidification using the brushing technique

The deacidification process was done by the brushing technique using a $CaCO_3$ and Na_2CO_3 solution of 0.1% and 1%. Firstly, the surface of the archive paper was brushed using the solution; the paper was then left to dry for a night to ensure the solution had been completely absorbed by the paper. The final pH measurements are shown in Table 3.

Table 3. Final pH measurements by brushing technique

No	Storage	Type of Paper	Initial pH	Final pH			
				$CaCO_3$ 0.1%	$CaCO_3$ 1%	Na_2CO_3 0.1%	Na_2CO_3 1%
1	Odner (1992)	Thin paper	6	6	7	7	10
		HVS paper	5	6	7	7	10
2	Box (1998)	HVS paper	7	7	7	9	11
		Thin paper	5	6	7	6	11
3	Bundled archives (1984)	Scribbing paper	6	7	7	7	11

Based on the final pH measurement using the brushing technique, it is known that $CaCO_3$ gives a moderate increase in the pH of the paper. The increase in pH is described by the chemical reaction in the paper. This happens because of the $CaCO_3$ in the water (solution) which acts as a weak base that produces $Ca(OH)_2$. The neutralization reaction occurs between the OH^- and acid substance in the paper. The Ca^{2+} from the solution bonds with the carboxyl anions in the oxidized cellulose. Thus, it decelerates the degradation of the paper. The remaining calcium ion will produce $CaCO_3$ to protect the surface of the paper [9].

Na_2CO_3 gives a higher pH and increases significantly when applying 1% Na_2CO_3. When Na_2CO_3 is dissolved in water, it produces a strong base. This research, also confirmed by Bansa [8]; Stefanis [10]; Botti [11], shows that calcium compounds perform better than other alkaline compounds for deacidification.

3.5. Deacidification using the spraying technique

The spraying technique was carried out using a sprayer with the same solution as that used for the brushing technique. The final pH measurements are shown in Table 4. The spraying technique gives similar results to the brushing technique. Based on Wojciak [12] it is known that the spraying technique gives a better dispersion of the compound on the surface of the paper.

Table 4. Final pH measurement by spraying technique

No	Storage	Type of Paper	Initial pH	Final pH			
				$CaCO_3$ 0.1%	$CaCO_3$ 1%	Na_2CO_3 0.1%	Na_2CO_3 1%
1	Bundled archives (1984)	Thin paper	5	7	7	6	8
2	Humid Odner (1985)	Scribbing paper	5	6	7	6	10
3	Box (1987)	Thin paper	5	6	8	7	10
		Scribbing paper	5	6	7	6	10
		HVS paper	5	5	7	6	10

4. Conclusion

Deacidification for archives conservation in the Singosari National Artificial Insemination Center (Balai Besar Inseminasi Buatan, BBIB) was carried out. Solutions of $CaCO_3$ and Na_2CO_3 at 0.1% and 1% respectively were applied by brushing and spraying techniques. Application of a $CaCO_3$ solution gives a moderate increase of pH and Na_2CO_3 gives a higher pH. Thus, application of $CaCO_3$ is appropriate for the deacidification of paper archives.

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Biographical notes

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Summary

Deacidification is a method used to neutralize acids that can damage paper and provide a buffer to protect paper from the effects of acid from the outside. This research is related to the application of deacidification for archive paper at BBIB Singosari. BBIB Singosari is the Singosari Center for Artificial Insemination (BBIB) and is a technical implementation unit (UPT) of the Directorate General of Livestock and Animal Health. The purpose of this research is to apply the deacidification process at the BBIB Singosari Center and observe the physical factors which have an effect on preservation efforts. High acidity levels cause damage to archive paper, staining it yellow, and making it brittle. The deacidification process can change the condition of the paper to alkaline. In this experiment, the deacidification process is done by means of brushing and spraying techniques using calcium carbonate ($CaCO_3$) and sodium carbonate (Na_2CO_3) solutions at 0.1% and 1%.

Riassunto

La deacidificazione è un metodo utilizzato per neutralizzare gli acidi che possono danneggiare la carta e fornire un tampone per proteggere la carta dagli effetti degli acidi provenienti dall'esterno. Questa ricerca riguarda la deacidificazione della carta d'archivio presso il Centro Singosari per l'Inseminazione Artificiale (BBIB): un'unità di implementazione tecnica (UPT) della Direzione Generale Zootecnia e Salute Animale. Lo scopo di questa ricerca è applicare il processo di deacidificazione presso il Centro BBIB Singosari e osservare i fattori fisici che influiscono sulla conservazione.

Livelli di acidità elevati danneggiano la carta d'archivio, ingiallendola e rendendola fragile. Il processo di deacidificazione può cambiare le condizioni della carta in alcaline. In questa sperimentazione il processo di deacidificazione avviene mediante tecniche di spazzolatura e spruzzatura utilizzando soluzioni di carbonato di calcio ($CaCO_3$) e carbonato di sodio (Na_2CO_3) allo 0,1% e all'1%.