A study of factors that may affect the deterioration of window furnishings
by Bernice Hirschman Eckhoff

A Thesis submitted to the Graduate Committee in partial fulfillment of the requirements For the Degree of MSTER OF SCIENCE IN HOME ECONOMICS
Montana State University

Abstract:
1. Sunlight transmitted through window glass is the factor which seems to have the greatest deteriorating effect upon window furnishings in this vicinity; 2. Heat up to 63.2° C. has very little deleterious effect upon window furnishings.

3. Moisture alone plays only a minor part in the deterioration of fibers but in the presence of sunlight there are definite losses in strength in cotton, linen, wild and degummed silk.

4. Lack of moisture has very little effect upon the deterioration of window furnishings.

A STUDY OF FACTORS THAT
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OF WINDOW FURNISHINGS

BY

BERNICE HIRSCHMAN ECKHOFF

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Approved:

Jessie E. Richardson
In charge of Major Work

Gladys Branegan
Chairman Examining Committee

R. E. Kirk
Chairman Graduate Committee

June 1931

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A STUDY OF FACTORS THAT MAY AFFECT THE DETERIORATION OF WINDOW FURNISHINGS

INTRODUCTION

Many textile fabrics are purchased for use in the home and are employed for numerous articles of clothing, table linens, bed linens, floor coverings, and window furnishings. Upon many of them falls a great deal of physical wear which eventually so damages the fibers, that they break and fall apart, thus rendering the fabric unfit for further use. This is to be expected whenever textile fibers are subjected to continual friction and strain.

In the case of window furnishings, the conditions are somewhat different. They are merely suspended in front of the windows that are found on all sides of buildings, with only a sheet of window glass separating them from the outside. Inside, they are not exposed to physical contact, wear, or handling but rather to the natural elements such as varying heat, humidity, air in motion, dust, and traces of gases that may occur in the air. Through the window glass is transmitted also a varying amount of heat from the sun's rays and whatever portions of the sun's light that is able to pass through the glass. This light may come directly from the sun or be reflected from snow on the ground, light colored soil, or light colored buildings. These factors together with the weight of the suspended curtain itself constitute the natural causes that are expected to deteriorate window furnishings.

The experience of homemakers in the western states, especially in mountainous regions, has drawn attention to the fact that a type of deterioration is taking place in window furnishings that is much more rapid and detrimental in its effect than has been noted elsewhere. This is particularly true of any form of silk fabric. The condition has aroused considerable interest among homemakers of Montana and is therefore worthy of some special study.

HISTORY

The textile fibers that may be found in window furnishings are cotton, linen, rayon, silk, and wool. In order to determine some of the causes of their rapid deterioration in the western states it will be necessary to assemble some of the information already known about each fiber as to its physical structure and properties, chemical composition, and the treatment it receives while being made into a fabric.

A Cotton

The individual cotton fiber is a single flat ribbon-like cell, with a diameter varying from .00046 to .001 inch and the length ranging from .93 inch in Indian varieties to nearly 2 inches in the Sea Island cotton. The density of cotton is 1.50. When examined under the miscroscope the fiber appears to be twisted in an irregular screw-like fashion. This occurs during the ripening and drying of cotton when the cells collapse and the central canal flattens. It seems to lend strength to the fiber and facilitates spinning.

Structurally, the cotton fiber appears to consist of four distinct parts: (a) the main cell wall, (b) an external cuticle, (c) the wall of the central canal, and (d) annular ligatures that surround the fibers at intervals. (1, p. 434)

The main cell wall is considered to be almost pure cellulose. According to Haller (1, p. 442) this is more or less colored, the pigment being resistant toward common solvents but destroyed by long contact with oxidizing agents. The membrane itself is completely soluble in ammoniacal copper hydroxide solution.

The external cuticle, probably a modified cellulose (1, p. 437) has a finely grained or fibrous structure, and is of a waxy or fatty nature, resistant to acids and cellulose solvents, but susceptible to the action of alkalies, and liable to mechanical damage. Pits or pores are said to occur in this layer. This accounts for the capillarity of cotton. Noyes suggests that the cuticle consists of a porous oxycellulose, that has great osmotic properties and is not acted upon by esterifying agents but allows them to penetrate into the fibrils. (1, p. 442)

The wall of the central canal consists of dried protoplasm attached to the membrane, and is even more resistant to cuprammonium treatment than the cuticle. The ligatures persist even after the canal walls are dissolved.

Cellulose, the chief constituent of cotton, consists of carbon, hydrogen, and oxygen and has the emperical formula $C_6H_{10}O_5$. Though cellulose is closely related to starches, dextrins, and sugars it differs from them in its much greater resistance to the hydrolytic action of acids, alkalies, and enzymes. Physically it is a colorless amorphous substance capable of withstanding rather high temperatures without decomposition, insoluble in water, alcohol, and ether but soluble in an ammonical solution of copper oxide and in solutions of zinc chloride and phosphoric acid. In its chemical relations it is practically inert combining with only a few substances. It is quite resistant to the processes of oxidation, reduction, hydrolysis, and dehydration. When subjected to 160° C., whether moist or dry heat, a dehydration of the cellulose takes place accompanied by a structural disintegration of the fiber. Decomposition occurs above 120° C. and the fiber acquires a yellowish color showing the beginning of carbonization. When cotton yarn is dried for twelve hours at 70° C. it loses about five percent of its tensile strength and much of its elasticity, becoming harsh and brittle. It rapidly regains its hygroscopic moisture on exposure to air and recovers its original strength. Cotton is less hygroscopic than either wool or silk; under normal conditions it will contain from 5 to 8 percent of hygroscopic moisture though this may be considerably increased in very moist atmosphere and completely eliminated by heating the cotton to 105° C. Kuhn (1, p. 460) states that a portion of this moisture must be regarded as a constituent part of the fiber. The water of constitution, he states, amounts to about 2 percent. It can be expelled at over 105° C.; and the fiber becomes harsh and brittle and loses its elasticity. This statement however deserves further investigation. The water of hydration is only separated at temperatures from 160 to 177° C. with a further loss in weight of 1 to 3 percent. Cotton containing water of hydration is called hydracellulose. Bleached cotton will absorb a little less hygroscopic moisture than unbleached. The increase in elasticity of moist yarn over dry is about 25 percent, while the increase in strength is about 10 percent. It has been found that cotton cloth frozen in full open width is not tendered.

Cotton purified from its waxy and fatty matters becomes very absorbent; in fact a fiber can absorb 115 times its volume of ammonia at the ordinary atmospheric pressure.

It is known that deterioration occurs when cotton fabrics are exposed to the action of light and especially direct sunlight. (1, p. 511) Witz showed that oxycellulose was formed from cotton in the presence of air and moisture. Guiard claims in this case it was more probable that hydrocellulose was formed. Witz exposed a cotton fabric during an entire summer under conditions in which air and moisture were excluded and only light was the active agent. He found the formation of oxycellulose on cloth exposed to blue rays but none on cloth exposed to yellow or red rays. Doree and Dyer found oxycellulose formed rapidly in the presence of ultra violet light. It was no doubt the violet and ultra violet rays that caused the destructive action of light on cotton cellulose. (1, p. 511)

The action of dilute mineral acids on cotton seems to be one of hydrolysis resulting in the formation of hydrocellulose having the formula $2\ C_6H_{10}O_5 \cdot H_2O$ with a reduction in strength. Organic acids do not appear to have an injurious effect on cotton unless they are non-volatile such as oxalic, tartaric, and citric acids which dry into the fiber and act much as mineral acids. This destructive action is not so much of a chemical nature as mechanical, it being caused by the acids crystallizing within the fiber and thus breaking the cell wall.

In the presence of air, alkaline solutions cause a hydrolysis of the cellulose. (1, p. 533) When cotton is impregnated with sulfur and exposed to a damp atmosphere for several weeks its tensile strength is reduced about one half. This is perhaps due to the oxidation of the sulfur into sulfurous and sulfuric acid.

Strong oxidizing agents such as chlorine convert cotton into oxy-cellulose, the formula of which is $C_{18}H_{26}O_{16}$. The fiber is greatly tendered.

In the manufacturing processes, bleaching causes a loss in weight, tensile strength, length, and elongation. Of the natural dyestuffs, only a few color the cotton fiber without a mordant which is an acid and is liable to cause reduction of strength. With coal tar dyes, cotton exhibits no affinity, but substantive colors are readily dyed on cotton, which seem to cause a gain in weight. In dying in alkaline baths tensile strength is weakened.

In mercerization the fiber is treated with concentrated solutions of caustic soda causing the fiber to swell and become cylindrical while the interior canal is almost entirely obliterated. There is a marked gain in weight and strength and an increased affinity for dyes.

Cellulose and starch are subject to destruction by mildewing which is the growth of moulds on the fabric.

B. Linen.

Linen is a fiber obtained from the flax plant. The fiber is prepared from bast of the plant by a process called retting. This separates the fibrous cellulose from the woody tissue and other plant membrane by bacterial action which ferments the pectose. The fiber is from 12 to 36 inches in length, and the color varies from yellowish white to silver gray depending upon the method of retting. It can be subdivided into soft, fine, flexible fibers which are very strong. The linen fiber is composed of filaments of varying lengths and these are composed of small cells consisting practically of pure cellulose. The internal canal is very narrow and the cell wall is quite uniform in thickness upon it occasionally appearing irregularities known as "nodes." The diameter of the filament varies from .006 to .00148 inch and the length, from 0.157 to 2.598 inches. The flax fiber is much stronger than that of cotton but due to differences in structure, is more easily disintegrated than cotton and does not so well withstand the action of boiling alkaline solutions, bleaching powder, or other oxidizing agents. On the surface of the flax fiber is found a characteristic wax which seems to be responsible for the odor and suppleness of flax. If this is removed by proper solvents, the fiber becomes rough, lusterless, and brittle. Over retting may also cause the fibers to become brittle and weak. The hygroscopic moisture in linen is about the same as in cotton usually varying from six to eight percent, and tests have shown that as the amount of moisture increases, the strength also increases to quite a remarkable degree.

C. Rayon

Rayon is a smooth continuous fiber which can be made in any length and varies from .0011 to .0014 inch in diameter. The threads vary from 120 to 150 denier with 16 to 25 filaments in each. The four chief types of rayon are:

(a) Pyroxylin or Nitro rayon, called "Tubize" which is made from cellulose treated with a nitrating mixture of nitric and sulphuric acids; the collodion solution being filtered, forced through a fine capillary glass tube, and reeled as a filament;

(b) Cuprammonium rayon, called "Bemberg" which is made from cellulose in ammonical copper oxide solution; the solution being filtered and forced through an aperture and coagulating the thread by passing through a bath of acetic acid and then reeled;

(c) Viscose rayon, called "Viscose" and "Belanose", which is prepared by the action of caustic alkali and carbon disulphide on mercerized cellulose, filtered, forced through an aperture for reeling, and being yellow is bleached with chloride of lime. These three rayons are classified as regenerated rayons.

(d) Acetate rayon called, "Celanese" and "Lustron" is made of acetate of cellulose dissolved in acetic acid, alcohol, or chloroform and spun, the thread being coagulated by passing through a bath of water. The silk corresponds to twice the weight of cellulose taken. This silk is less stable towards acids and alkalies than collodion silk nor does it dye as readily. It is not affected so much by heat or cold water, but its strength is not much greater than other cellulose silk. Acetate silk is soluble in cold acetic acid but insoluble in ammonial copper hydroxide. It is distinguished from other rayons by its low density (1.25) and by not swelling in water. It does not have the high luster of viscose or cuprate rayon nor does it absorb moisture as readily as the others.

The tensile strength and elasticity of rayon is about one half that of silk. When wetted with water regenerated rayon fibers swell and lose from 50 to 70 percent in tensile strength; cuprate silk is about 10 percent stronger. Rayon is more hygroscopic than cotton with an average hygroscopic moisture of 11.3 percent. Soap solutions and dilute acids have no injurious effect, but alkaline solutions rapidly disintegrate rayon and finally dissolve it. Rayon wears well because it is pliable, and its smooth surface resists friction. Regenerated rayon is not injured by the action of acetic acid and does not provide a favorable medium for the growth of bacteria.

D. Silk

Raw silk is composed of a double fiber of the protein, fibroin, cemented together by an enveloping layer of silk glue called sericin, which when boiled off allows the double threads to separate, leaving a single, white, lustrous fiber. Silk is not cellular but a smooth continuous filament devoid of structure and with frequent striations. The fiber is from 400 to 1300 yards in length and has an average diameter of 0.018 inch.

Silk is quite hygroscopic and can absorb as much as 30 percent of its weight of moisture appearing dry. The amount of moisture in silk is about 8.45 percent.

Silk has great strength, the breaking strain of raw silk being equivalent to 64,000 pounds per square inch. The fiber stretches 15 to 30 percent of its original length before breaking. However, boiled-off silk is about 30 percent lower in tensile strength and 45 percent lower in elasticity than raw silk. The density of silk is 1.25; it is the lightest of the textile fibers. The density is increased by weighting. The weighting consists of metallic salts.

Raw silk is classified into two grades: (a) Organizine silk of great strength, 16 twists per inch and used for the warp. (b) Tram, a union of two or more singles of poorer quality with from 2 to 3 twists per inch, used as filling.

Silk can be heated to 110° C. without danger of decomposition; at 170° C. it is rapidly disintegrated.

Silk being highly absorbent will absorb dissolved substances in water which seriously affect its softness and luster.

Though silk is soluble in concentrated acids if their action is continued for a time, when treated with concentrated sulphuric acid for a few minutes, then rinsed and neutralized, the fiber contracts from 30 to 50 percent in length without further serious injury beyond loss in luster. Silk is not as sensitive to dilute alkalies as wool though the luster is diminished. Strong hot caustic alkalies dissolve silk. Ammonia and soaps dissolve the sericin and on long boiling attack the fibroin. Borax is not injurious to the fiber. Lime water causes the fiber to swell, the sericin will become softened and the silk will become brittle after a time.

Silk is weighted or loaded with metallic salts to give it body. The tensile strength of weighted silk is less than of pure, and the weighting sometimes causes a rapid deterioration of the fiber. Sunlight seems to accelerate the destructive action of tin weighting, though according to Siberman the effect is reduced if stannous salts are absent (1, p. 306). Gianoli states that this reactivity of the tender silk is due to decomposition products of the silk resulting from the effects of oxidation and hydrolysis upon the silk fibroine. When exposed to sunlight in the absence of moisture or air the fiber is not tendered but in their presence is seriously affected. (1, p. 306) Treatment of weighted silks with hydro-sulfite-formaldehyde compounds decreases the tendering action of weighting material. This process is of commercial use. According to Sisley solutions of common salt acting on weighted silk in the presence of air and moisture cause a complete deterioration of the fiber in twelve months.

Wild silk is stiffer, coarser, and thicker than ordinary silk possessing greater elasticity and tensile strength. It is less reactive to the chemical agents.

E. Wool

Wool is a product of the epidermal layer of the skin built up of innumerable individual cells, and consists of three portions (a) external or horny covering, (b) cortical or underlying body of fiber, (c) medullary or central portion. This structure affords strength to the fiber in that it resists crushing, rupture and diminution of the diameter. Under the microscope wool fiber appears as a solid rod, the surface of which is covered with broad horny plates all projecting in the same direction. The average length of wool varies with different grades from 1 to 8 inches, and the diameter from .004 to .0018 inch.

Wool is a very elastic fiber. The quality of wool from the sheep depends upon bread, climatic conditions, and nature of pasturage. The quality of a woolen fabric may be impaired by overheating during the fulling process; by dressing or raising in which process lack of moisture, too strong, testing, or over treatment occur; by roll boiling in which expansion causes strain; by carbonizing in which too strong an acid may be used; by cutting in which upper threads are severed in the attempt to remove superfluous fibers.

Wool is a protein known as keratin and is composed of carbon, hydrogen, oxygen, nitrogen, and sulphur.

Wool is more hygroscopic than any other fiber, but the amount of moisture it will contain, from 1 to 30 percent, will vary considerably according to the humidity and temperature of the surrounding atmosphere. Under average conditions it will contain from 12 to 14 percent of absorbed moisture. Wool fiber possesses a certain amount of water of hydration which is probably chemically combined with the fiber, as when wool is heated above 100° C. it becomes chemically altered through the loss of water.

Excess of moisture over the normal amount appears to decrease tensile strength of worsted yarns while it increases considerably the elasticity. Silk follows the same variation. Changes in atmospheric conditions increase or decrease worsted yarns as much as 18 to 22 percent in tensile strength, 1.5 to 3 in yarn count, and from 250 to 1,700 yards per pound. The atmospheric conditions recommended are 65 percent relative humidity, at a temperature of 70° F. (1, p. 136)

When wool is heated to 100° C. it loses its hygroscopic moisture becoming harsh, brittle, and losing its tensile strength. Being heated in moist atmosphere to 100° C. causes the fiber to become plastic and if maintained at this temperature will decompose; at 130° C. decomposition is rapid, wool becomes yellow, and ammonia is evolved. At 140° C. gases containing sulphur are evolved. By heating wool to a temperature of 130° C. with water under pressure the fiber becomes disorganized and at a higher heat dissolves. Dry heat is not as destructive to wool as moist.

When treated with dilute acids the wool fiber does not undergo any appreciable change, but a chemical combination probably occurs, since the acid is absorbed and held by the fiber. When treated by prolonged boiling of dilute acids some decomposition results with complete solution of the fiber when boiled under pressure. Wool is totally destroyed by the action of concentrated mineral acids. Although so resistant to the action of acids, wool is quite sensitive to alkalies. A 5 percent solution of caustic soda at a boiling temperature will completely dissolve wool in a few minutes. The fiber was not disintegrated after being boiled for three hours with 3 percent caustic soda but with 6 percent was entirely dissolved. Reducing agents increase the strength and luster of the fiber. The fiber is readily oxidized when treated with oxidising agents and is deteriorated greatly. By moist chlorine gas wool is destroyed but is not so affected by the chlorination process which gives it a silk-like feel. Wool is more easily damaged by chlorine than hypochlorous acid the excess of which causes destruction of epithelial and cortical scales.

With regard to coloring matter wool is the most reactive of all the textile fibers, combining directly with acid, basic, and most substantive dyestuffs, and yielding as a rule shades which are much faster than those obtained on other fibers.

If left in a warm place, in a moist condition without access to fresh air, mildew or fungoid growth develops on the fiber tendering and eventually rotting it.

It appears from the preceding discussion that each of the textile fibers used in window furnishings is affected to a certain degree by the leading external deteriorating influences.

Heat, a form of molecular energy, is capable of changing a body in volume and physical condition. It is transmitted to curtain materials by means of convection currents set up by heating devices within buildings and also by radiation and convection from the window glass that receives the direct rays of the sun. Convection currents cause a motion in the air, so that in passing through the fabric, friction to the fibers may result. Heat also brings about expansion of the molecules which probably results in elongation of the fiber as the weight of the hanging curtain exerts a continuous strain upon the fiber. On the other hand, curtain materials are often subjected to extreme cold as they hang close to the chilled glass. This undoubtedly contracts the fibers which may result in a tendering.

Heat also brings about a dehydration of fabrics which usually results in a loss of tensile strength and often produces a brittle condition in the fiber. Light, a form of radiant energy, is transmitted through the glass either directly from the sun or by reflection as previously described. It is recognized that ordinary window glass permits little or none of the ultra violet portion of the spectrum that is capable of producing oxycellulose, to pass through, but the blue rays of the spectrum do penetrate glass and are believed to have deteriorating affects upon fabrics.

The humidity or moisture contained in the atmosphere seems to have a close relationship to the tensile strength of fibers. With too small amounts of moisture the fiber becomes dry, weak, and brittle, and with excess of moisture the rayon and wool show weakened conditions. For each fiber there is an optimum amount of humidity that is often controlled by the existing temperature.

The air with its content of oxygen, nitrogen, carbon dioxide, aqueous vapor, dust, and traces of ozone, ammonia, and other fumes comes into very close contact with curtain materials as it moves between the fibers of the fabric. Oxygen and ozone tend to cause oxidation, dust particles grind into the fabric causing tendering, while variations in water content affect the strength.

Acid fumes from fuel are especially detrimental to fabrics made of cellulose. Ammonia brings about the tendering of wools and rayons.

With this information about each fiber and the factors that might cause deterioration, a study was begun attempting to determine what factors are causing the more rapid deterioration of window furnishings in the western states.

EXPERIMENTAL PROCEDURE

In order to secure some definite information regarding the habits of homemakers in selecting and caring for window furnishings and their experience with the wearing qualities of the fabrics selected, a questionnaire was formulated to use in personal interviews. By this means an attempt was made to learn about the following:

A. Selection of window furnishings
  a. Materials selected for window shades, glass curtains, hangings, and rods for the living room, dining room, bedroom, bath room, and kitchen
  b. Reasons for the selection of each

B. Care of window furnishings
  a. Frequency of cleaning
  b. Method of cleaning
  c. Place of cleaning

C. Wearing qualities of window furnishings.
  a. Service given
  b. Retention of color
  c. Shrinkage
  d. Effect of hanging at an open window

(Copy of questionnaire in Appendix p. 56)

From the data obtained in these interviews it was learned which fabrics representing cotton, linen, rayon, and silk were commonly used in the home, and these fabrics, natural in color, were selected for testing in the laboratory as follows: cotton, marquisette; linen, theatrical gauze; rayon, bemberg; silk, silk gauze; and wild silk, pongee.

From each fabric samples were cut 5 inches in from the selvedge measuring 5 inches on the warp and 15 inches on the filling. Each sample was weighed on a gram balance, and ten sets containing one sample of each fabric were assembled. In order that each set might be influenced by a certain deteriorating factor or combination of factors, the sets were exposed from November 4th until May 4th in the following manner:

Set one was arranged on a frame and placed in a window of southern exposure. So that each fabric might hang as it naturally would when used as a curtain, a wooden frame 12 inches wide and 30 inches long was made, equipped with soft cotton cords, representing rods, onto which the fabric was run, a narrow casing being basted along the top of each sample. The position of the five samples on each frame was such that no shadows were cast from the window frame onto the fabric. The samples were subjected to the sun's light and heat and the condition of heat and humidity prevailing in the room. Set two was arranged on a similar frame and placed in a window of northern exposure. This differed from set one having only reflected light from the sun. Set three was also arranged on a frame and placed in a dark closet which was kept well ventilated and at room temperature. In this case the direct heat and light from the sun were omitted. Set four was placed on a similar frame. To expose this set to high humidity, a box 30 inches high, 12 inches wide, and 12 inches deep was made of celotex, in it was placed a pan 9 inches long, 3 inches wide, and 3 inches deep always kept full of distilled water into which six lamp wicks were lowered to a depth of 2 inches, and the frame containing the curtain sample was fitted into the front of this box. This set was then placed in a window of southern exposure. The condition of moisture was added to the factors for set one. Set five was arranged the same way as set four but placed in a dark closet which was kept well ventilated and at room temperature. The factors were as those of set four with the omission of light. Set six was put into a pasteboard box which was wrapped with paper and sealed. It was placed in a drying drawer where the temperature varied from 60 to 70° C. This set was subjected to high temperature with no ventilation or light and practically no moisture. Set seven was prepared as set six and placed in an electric refrigerator kept at about 3° C. This differed from set six in that cold was substituted for heat. Set eight was put into a similar box and placed in a desiccator in which soda lime was the drying agent. Here there was no moisture, light, or ventilation, and only room temperature. Set nine was placed in the same glass desiccator but not wrapped. The desiccator was set near a window of southern exposure so that direct sunlight was able to reach these samples. A thermometer was also put in the desiccator so the temperature could be recorded without opening it at any time. Set ten was placed in a wrapped, sealed, pasteboard box in a drawer at room temperature as a control.

At the beginning of the experiment certain laboratory tests were made. The weight of each sample was taken in grams as given in Phelps Manuel p. 77. The number of yarns per inch was found by the thread counter. (2, p. 78) The number of twists per inch of yarn was calculated by the precision twist counter. (2, p. 87) The tensile strength of the fabric was determined by the strip test method. The length of the specimens was 7 inches, the width $1\frac{1}{2}$ inches, and the distance between the jaws 3 inches. (2, p. 80) The bursting strength was taken on the Mullen tester. (2, p. 83).

At the end of the six months' study the tests which were repeated on each sample of window fabric were: weight, tensile strength of fabric, and bursting strength.

During this six months' period, temperature records were kept for each set. External light conditions were recorded so that the kinds of daylight during the exposure might be known. Actinic measurements of solar ultra violet light were made according to the methods worked out by the laboratory of the Chicago Health Department. (3, p. 493-511)

Fading tests were run on two sets of samples containing fabrics of cotton, linen, rayon, silk and wool of various colors. Each set was made as follows: Swatches $2\frac{1}{2}$ inches by $4\frac{1}{2}$ inches of the fabrics were mounted on a thick cardboard over which was sealed with gummed paper a cardboard of the same size on which circles one inch in diameter were cut out allowing that area to be exposed on each fabric. One set was exposed to 300 hours of sunlight inside a south window, the other was exposed outside this window for the same length of time. In order that each fabric might be exposed to the light as it would be when used for a window material they hung parallel to the window no definite angle of light being observed.

RESULTS

Following the methods that have been outlined, a study of window furnishings was conducted during a seven months' period extending from October 15, 1930, to May 15, 1931. During this time information was secured from homemakers regarding their methods of selection and care of window furnishings and their experiences with wearing quality. At the same time a series of standard laboratory tests were applied to a few selected materials that were exposed to controlled combinations of external factors believed to be causes of deterioration. The results from each of these investigations will now be presented.

A. Data Furnished By Homemakers

One hundred three homemakers were personally interviewed, and a questionnaire was filled out for each one from which the following data was tabulated.

In tables I, II, III, and IV will be listed the kinds of window shades, glass curtains, window hangings, and curtain rods used respectively in the homes visited and the room in which each kind was found.

TABLE I. NUMBER OF ROOMS IN WHICH DIFFERENT KINDS OF WINDOW SHADES WERE USED.

Kinds of window shades	Living room	Dining room	Bed-room	Bath room	Kitchen
(a) Roller Shades					
Water-color	4	4	3	3	5
Machine-oiled	80	77	77	77	76
Hand-painted					
Single	0	6	5	5	5
Duplex	3	4	4	4	4
Tontine	3	3	6	6	6
Austrian cloth	2	2	1	0	0
Imported Holland	1	1	0	0	0
Domestic Holland	2	0	2	2	2
Indian Head	1	1	2	1	1
(b) Pull Curtains					
Damask	5	0	1	0	0
Homespun	1	0	0	0	0
Rayon taffeta	1	0	0	0	0
Rayon madras	0	2	0	0	0
Mohair	0	0	1	0	0
Cretonne	0	0	1	1	0
Chintz	0	0	0	1	1
Oilcloth	0	0	0	1	1
Linen Crash	0	0	0	0	1
None	0	3	0	2	1

TABLE II. NUMBER OF ROOMS IN WHICH DIFFERENT KINDS OF GLASS CURTAINS WERE USED.

Kinds of Glass Curtains	Living room	Dining room	Bed-room	Bath room	Kitchen
Bemberg	4	4	0	1	0
Battenberg lace	2	2	0	0	0
Casement cloth	1	0	3	0	0
Cotton madras	8	4	6	0	2
Cotton marquisette	23	23	45	42	50
Cotton scrim	1	3	0	14	4
Cotton voile	1	2	26	8	8
Dimity	0	0	0	0	4
Dotted Swiss	0	0	5	7	4
Dupont fabroid	0	0	0	0	1
Filet net	13	13	5	11	5
Gingham	0	0	0	0	2
Grenadine	0	1	0	0	0
Japanese crepe	0	0	0	1	0
Lace	10	9	3	1	0
Lawn	1	0	0	3	6
Muslin	0	0	0	1	2
Organdie	0	0	1	4	4
Pongee	1	0	0	0	0
Rayon brocade	0	0	0	0	1
Rayon madras	1	0	1	0	0

TABLE II (Cont'd)

Kinds of Glass Curtains	Living room	Dining room	Bed-room	Bath room	Kitchen room
Rayon marquisette	14	10	3	0	0
Rayon net	4	3	1	0	0
Theatrical gauze	2	2	1	0	0
Quaker net	1	7	0	0	0
None	16	20	3	10	10

TABLE III. NUMBER OF ROOMS IN WHICH DIFFERENT KINDS OF WINDOW HANGINGS WERE USED.

Kinds of window hangings	Living room	Dining room	Bed-room	Bath room	Kitchen
Alpaca-rayon	1	0	0	0	0
Cambric	0	0	1	0	1
Chintz	2	0	3	0	0
Crash-linen	0	0	0	0	1
Crepe	0	0	3	0	0
Corduroy	0	1	0	0	0
Cretonne	6	14	9	3	2
Damask (rayon)	16	11	3	0	0
Damask (silk)	6	0	0	0	0
Dimity	0	0	0	0	1
English linen	3	4	1	0	0
Gingham	0	0	0	1	1
Homespun	2	0	0	0	0
India print	0	0	1	0	0
Japanese crepe	0	0	1	0	0
Marquisette	3	2	2	1	0
Mohair	3	1	1	0	0
Muslin printed	0	0	2	0	0
Net (rayon)	3	1	0	0	0
Organdie	0	0	1	0	0
Pongee	0	0	1	0	0

TABLE III (Cont'd)

Kinds of window hangings	Living room	Dining room	Bed-room	Bath room	Kitchen
Rep	2	0	0	0	0
Sateen	0	1	1	0	0
Satin	0	0	3	0	0
Shantung (silk)	1	0	0	0	0
Taffeta	2	1	3	0	0
Tapestry	2	1	0	0	0
Terry cloth	1	0	0	0	0
Velour	2	3	0	0	0
Voile	0	0	17	0	0
None	48	63	50	98	97

TABLE IV. NUMBER OF ROOMS IN WHICH DIFFERENT KINDS OF CURTAIN RODS WERE USED.

Kinds of Rods	Living room	Dining room	Bed-room	Bath room	Kitchen
Spring	0	0	2	6	8
Round straight brass	2	2	1	9	9
Round extension brass	11	13	10	1	2
Flat straight extension	3	3	5	7	4
Flat curved end extension	66	64	83	77	78
Double curved end extension	1	1	0	0	0
Wrought iron	9	8	2	1	1
Cast-iron	2	1	0	0	0
Wood	9	8	0	0	0
None	0	3	0	2	1

The preceding tables indicate that a wide variety of materials are being selected by homemakers for their window furnishings. Each homemaker was questioned as to what influenced her in making her selections, and the reasons for buying are summarized in Table V.

TABLE V. NUMBER OF TIMES THE FACTORS LISTED BELOW INFLUENCED HOME-MAKERS IN THEIR SELECTION OF WINDOW FURNISHINGS.

Factors	Window Shades	Glass Curtains	Hangings	Rods
Personal likes	47	94	63	75
Ideas of others	46	6	1	3
Interior decorator's advice	3	14	11	5
Store displays	0	4	1	0
Salesman's advice	0	0	0	0
Fashion or fad	9	1	1	9
Color	33	60	57	4
Design	0	11	5	0
Texture	8	50	47	0
Width	0	0	2	1
Appropriateness	10	34	21	2
Cost	11	41	14	7
Wearing qualities	24	25	7	11
Ease of cleaning	8	19	2	0
Ease of making	2	4	1	0

In view of the fact that certain natural elements, such as the dust and fumes present in the atmosphere of houses, are believed to be partly responsible for deterioration of window furnishings, it seemed advisable to investigate the frequency and methods of cleaning these fabrics.

Tables VI, VII, and VIII list the occurrence of methods used by homemakers in caring for their window furnishings.

TABLE VI. NUMBER OF TIMES METHODS OF CARING FOR WINDOW SHADES WERE USED.

Methods of care	Living room	Dining room	Bed-room	Bath room	Kitchen
(a) Frequency of Cleaning					
Once each two years	4	4	4	3	3
Once yearly	25	23	25	24	25
Twice yearly	64	64	64	64	64
Three times yearly	6	5	6	6	6
Four times yearly	2	2	2	2	2
Six times yearly	1	1	1	1	1
Twelve times yearly	1	1	1	1	1
(b) Method of Cleaning					
Dry wiping	75	75	75	75	75
Damp wiping	19	17	19	17	18
Cleaning gum	7	6	7	7	7
Scrubbing	2	2	2	2	2

TABLE VII. NUMBER OF TIMES METHODS OF CARING FOR GLASS CURTAINS WERE USED IN VARIOUS ROOMS.

Methods of care	Living room	Dining room	Bed-room	Bath room	Kitchen
(a) Frequency of cleaning					
Once each three years	4	3	0	0	0
Once each two years	3	3	1	0	0
Once yearly	32	27	14	3	1
Twice yearly	43	45	48	24	13
Three times yearly	5	5	16	16	17
Four times yearly	0	0	14	27	28
Six times yearly	0	0	6	22	22
Twelve times yearly	0	0	1	1	12
(b) Place of cleaning					
At Home	27	32	80	82	84
At Laundry	60	51	20	11	9
(c) Method of cleaning					
Hand washing	35	40	63	60	67
Washing on board	5	3	3	2	1
In machine	7	5	23	29	24
Dry cleaning	40	35	11	2	1

TABLE VII (Cont'd)

Method of care	Living room	Dining room	Bed-room	Bath room	Kitchen
(d) Method of drying					
*Stretching	62	53	25	14	10
Hanging outdoors	20	20	48	43	43
Hanging indoors	5	10	27	36	40

*The glass curtains sent to the laundry were placed on stretchers.

TABLE VIII. NUMBER OF TIMES METHODS OF CARING FOR WINDOW HANGINGS WERE USED IN VARIOUS ROOMS.

Methods of care	Living room	Dining room	Bed-room	Bath room	Kitchen
(a) Frequency of cleaning					
Once each three years	5	2	3	0	0
Once each two years	10	5	0	0	0
Once yearly	25	22	13	1	0
Twice yearly	15	11	16	1	2
Three times yearly	0	0	2	2	3
Four times yearly	0	0	2	0	0
Six times yearly	0	0	0	1	1
(b) Place of cleaning					
At Home	18	16	19	5	6
At Laundry	38	24	17	0	0
(c) Method of cleaning					
Washing	6	8	19	4	6
Dry cleaning	50	32	17	1	0

Where curtains were laundered at home nine brands of soap were used.

Brands used	Number of homemakers using
White King	25
Lux	20
Ivory	20
Ivory Flakes	12
Crystal White	10
P and G Naptha	5
Fels Naptha	5
Chipso	3
Oxydol	3

In tinting curtains the following coloring materials were used.

Materials used	Number of homemakers using
Tintex	10
Putnam's	5
Dipit	4
Coffee	3
Rit	3
Tea	2
Aladdin Soap	2
Twink	2
Tumeric	1
Gasoline and oil paint	1
Tissue paper	1

Thirty eight homemakers starched their glass curtains. In ironing curtains, eight used electric ironers, while the others used a flat iron. The curtains which were stretched did not require ironing.

In talking with the homemakers the idea seemed to predominate that the wear was closely related to the price paid for the fabric, except in the case of silk where even high priced materials deteriorated rapidly, especially in windows of southern exposure.

Rayons appeared to be wearing well although their extensive use has been too recent to form any definite conclusions.

Among the cotton fabrics used for glass curtains, marquisette with its lappet weave is giving the greatest satisfaction. It is not only durable but can be purchased in a variety of designs and colors making its use adaptable to any room.

Wools are very durable. Mohair, being wirey, resists dust so does not have to be cleaned so frequently. However, wool is susceptible to destruction by moths and must be protected.

It was believed that almost all of the glass curtains faded, after exposure to the sun, some more than others. As a rule, cheap window hangings faded much more rapidly than the expensive, many of which were sun fast. Hangings showed less fading when they were lined, and those exposed in southern windows were apt to become faded and streaked.

Cotton, linen, and rayon fabrics shrink upon being washed, so curtains are placed on stretchers when commercially laundered. Homemakers either allow for shrinkage in tucks or stretch the curtain in some way during the cleaning process. Some curtains were even placed at the windows while damp with a rod also run through the bottom on which were placed weights. Even though curtains shrink, the original length may be obtained again by stretching.

When the homemakers were asked what effects open windows had on curtains, their response was as follows:--

Effect	Number of homemakers
Have no effect	16
Catch dust	70
Deteriorate	51
Shrink	27
Fade	47