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**Some Effects of Common Processing
Conditions upon the Mohair Fibre**

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SOME EFFECTS OF COMMON PROCESSING CONDITIONS UPON THE MOHAIR FIBRE

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ABSTRACT

The effect of common processing conditions such as dry heat, steam, aqueous treatments of different pH and oxidising agents upon the mohair fibre was examined in terms of changes in mass loss, yellowness index and urea-bisulphite solubility. A Corriedale wool was used as a reference.

Mass losses arising from aqueous treatments were greater for mohair than for the wool.

No great differences between the fibres in their respective tendencies to yellow were observed.

Urea-bisulphite changes indicated that mohair was modified to a lesser extent than wool under mild conditions but that this position was gradually reversed with increasing severity of treatment.

INTRODUCTION

The mohair fibre is probably best known for its high lustre. It may be regarded as a luxury fibre and finds application in the manufacture of scarves, rugs, high quality suitings upholstery, curtaining and blankets. Demand, and therefore price, are subject to fluctuation.

Recent bibliographies^{1, 2} relating to the fibre and its properties suggest that little attention has been paid to the effects of common processing conditions upon the fibre. Kriel³ examined the modifications of wool and mohair by short term alkaline treatments but the conclusions would appear to be influenced by the great difference in fibre diameter between the two fibres. Strydom⁴ has examined the influence of wet processing upon the yellowing of mohair and concluded that yellowing was mainly dependent on time and temperature and to a lesser extent on pH.

Swanepoel⁵ compared the dyeing behaviour of wool and mohair of similar diameter and concluded that the rate of dyeing of mohair was faster than that of wool and that although the equilibrium exhaustions were identical, the mohair appeared the more deeply coloured by some 20 — 40 per cent when visual assessments were made. The faster rate of dyeing was attributed to the supposed larger proportion of ortho-cortex in the mohair and the apparent difference in depth between the two fibres, dyed to the same nominal depth, was attributed to the greater lustre of the mohair resulting from the smoother scales.

The purpose of this work was to examine the effects of common

processing conditions upon mohair compared with wool fibres of similar diameter. Three parameters were measured, namely, loss in mass, urea bisulphite solubility and yellowness index. The first gives an overall view of damage, the second an indication of intermolecular bond modification and the third is presumed to illustrate changes in the cuticular layers besides being of considerable interest to commercial processors of mohair.

Further work on the dyeing characteristics of mohair compared with wool will be the subject of a separate paper.

EXPERIMENTAL

Purification:

Mohair fibre (young goats), of mean diameter $32\mu\text{m}$ and Corriedale wool fibres of the same mean diameter were used throughout the investigation. The Corriedale was selected on account of its lustre in order that differences between the mohair and wool in this respect should be minimal.

The fibre was purified by successive extractions with diethyl ether and ethanol. After the ether extraction, the fibres were dried and shaken to remove grit and other extraneous material. Following the alcohol extraction the fibres were washed in running water for 24 hours to remove suint and more dirt. Drying was carried out at ambient temperature. The fibres were then passed through an F.O.R. Worsted card which served to further clean the bulk and to produce a homogenous sample. Finally the fibres were rewetted and allowed to come to equilibrium under standard atmospheric conditions of 65 *per cent* RH and 20°C .

Processing treatments:

The common processing agents selected for study and the conditions of treatment were as follows:-

Dry heat at temperatures of 70°C and 105°C respectively for periods of up to 8 days.

Steam at temperatures of 100°C , $108,5^{\circ}\text{C}$, $115,3^{\circ}\text{C}$ and 122°C respectively for periods of up to 120 minutes.

Acid conditions: Two solutions were employed, one of pH 2,07 prepared from 0,05 M hydrochloric acid and 0,09 M potassium chloride — the other of pH 4,70 prepared from 0,01 M acetic acid and 0,01 M sodium acetate. Temperatures of 25°C , 50°C , 75°C and 100°C respectively were employed for periods of up to 120 minutes.

Alkaline conditions: Two solutions were employed, one of pH 9,18 prepared from 0,05 M borax and another of pH 11,72 prepared from 0,01 M trisodium phosphate. Conditions of temperature and time were similar to those

used in the acid treatments.

Hydrogen peroxide: Solutions of 2 volume strength were employed at temperatures of 50°C and 75°C respectively, for periods of up to 16 hours. Experiments were conducted at pH 8,5 adjusted with ®Stabiliser C and at pH 4,2 adjusted with formic acid and sodium carbonate.

Most of the fibre treatments were conducted in a standard manner. Samples of conditioned fibre of approximately 3,5 g were accurately weighed and dipped into a wetting-out bath containing 0,5 g/l ®Nonidet P40 and allowed to drain before being treated with the selected agent under appropriate conditions, after which they were rinsed, neutralised when necessary, rinsed with water and allowed to reach equilibrium with standard atmospheric conditions.

Neutralising solutions were prepared from 0,25 *per cent* solutions of ammonia, acetic acid and sodium metabisulphite, respectively.

Departures from this standard pattern occurred only in the work on the effects of dry heat and steam. In neither case were the fibres wetted out prior to treatment. After completion of treatment, the dry treated samples were wetted out briefly before being allowed to reach equilibrium from the wet side. Treatments with steam were carried out in a domestic pressure cooker.

Method of assessment of fibre modifications:

Loss in mass was calculated as the difference in mass between untreated and treated conditioned fibres.

The urea-bisulphite solubility was determined by the IWTO (October 1965) method. It was preferred to alkali solubility measurements since the latter is not recommended for use with fibres which have already received alkaline treatments.

The Yellowness Index was calculated from the Hunter formula⁶:

$$\text{Yellowness Index (Y)} = \frac{X - Z}{Y} \times 100$$

where X, Y and Z are the tristimulus values.

The tristimulus values were measured on a Harrison-Shirley Digital Colorimeter. Four measurements were taken for each sample, two from each side; those from each side being taken at 90°C to each other.

RESULTS AND DISCUSSION

A. Urea-Bisulphite Solubilities:

The changes in urea-bisulphite solubility of keratin fibres arising from treatments with various agencies are now well known. Alkali and heat tend to decrease the solubility while an increase is induced by acids and oxidising agents.

Before considering the effects of the various treatments upon the urea-bisulphite solubilities of the fibres, it is important to consider the results for the untreated fibres.

Dusenbury⁷, in his paper on the characterisation of cortical structures by means of urea-bisulphite solubilities concluded that low values correspond to high paracortical contents while high values indicate a high ortho-cortical content. Hence the urea-bisulphite solubilities in this work would suggest that the mohair is richer in ortho-cortical material than is the wool. Dusenbury and Menkart⁸ claimed that mohair is richer in ortho-cortical material than is merino wool. It is, however, interesting to note that Kritzinger⁹ and Van Wyk and Louw¹⁰ observed variations in the urea-bisulphite solubility of from 70 *per cent* down to 10 *per cent* in South African merino wools and, further, claimed that those wools having a low solubility also showed an extremely alkaline aqueous suint extract. Thus it appears likely that the well known conversion of cystyl to lanthionyl groups under alkaline conditions may well commence while the fibre is still attached to the animal. It follows that the urea-bisulphite solubility should not be regarded simply as an indication of the relative ortho- and para-cortical contents.

Dry heat produces the expected drop in urea-bisulphite solubility, Fig 1a. At the lower temperature of 70°C, little difference is apparent between the two fibres but at the higher temperatures of 105°C, a three day exposure produces a decrease in urea-bisulphite solubility of 38 *per cent* in the mohair and 29 *per cent* in the wool. It is claimed that heat produces a consolidation of the cortex and that this effect is more pronounced in the case of the more accessible ortho-cortex. Thus the greater effect on the mohair may be caused by its higher ortho-cortical content.

The urea-bisulphite solubility figures for the effects of steam are shown in Figs 2a and 3a. At low steaming temperatures the mohair is less susceptible than the wool but with increasing severity of conditions the mohair becomes modified to a greater extent. Short term steaming treatments result in the mohair becoming modified to a lesser extent than wool but the position gradually reverses with increasing time of exposure.

It is argued¹¹ that the ortho-cortical material is rich in intramolecular disulphide groups and that these would be less inclined to be converted to lanthionyl groups than intermolecular cystyl groups, and since the mohair is the

richer in ortho-cortical material, it is possible that the lag in cross-link modification arises from this factor.

The effects of distilled water show the same pattern but to a lesser extent, presumably because of the milder conditions. Fig 4a shows an almost lineal drop in the urea-bisulphite solubility of mohair with time for treatments at 100°C whereas the wool shows an initial steep fall followed by a much shallower decrease. From Fig 5a it would appear that conditions are of only moderate severity so that the initial more rapid change in the urea-bisulphite solubility of the wool is evident but not the subsequent increase in rate of modification of the mohair.

The influence of solutions of different pH may be seen in Figs 6a-9a. Figs 6a and 7a show the effects of strong acid, pH 2,07 such as might be found in dyeing with 1:1 metal complex dyes. In this situation, the urea-bisulphite solubility is influenced by two opposing forces, namely, that of heat tending to reduce the solubility and that of acid tending to increase it. It will be noticed that at low temperatures and short times there is little or no change in the solubility but under more severe conditions the mohair suffers less change than the wool.

The effects of weak acids, though not shown here, were found to be similar to those described above with the trends less marked. Treatment under weak alkaline conditions, such as may be experienced during scouring, is shown in Figs 8a and 9a. They indicate that at low temperatures the mohair is modified to a lesser extent than the wool but at high temperatures the initial fall in solubility is much greater for mohair than for wool.

Hydrogen peroxide under both acidic conditions (pH 4,2) and alkaline conditions (pH 8,5) has a greater effect upon the wool than the mohair. Once again there exists the opposing influences of heat, pH and oxidising agent, but, under all conditions studied, the urea-bisulphite solubility showed a more rapid rise for wool than for mohair. These results are shown in Figs 10a and 11a.

B. Yellowness Index:

The yellowness of wool has been extensively studied and although it would appear that no simple explanation is possible, most workers are of the opinion that yellowing involves the modifications of amino acid. It is not the function of this publication to interpret changes in yellowness in terms of amino acid modification but it is nevertheless useful to be aware of the nature of the changes.

The effects of dry heat on both fibres is shown in Fig 1b. At the lower temperature there seems little difference in the respective tendencies to yellow but at the higher temperature of 105°C the rate of yellowing of the mohair is less than that of the wool.

The effects of steam are shown in Figs 2b and 3b. As the steaming temperature increases there is a greater increase in yellowness of the wool than mohair. Increasing time shows the same trend.

The influence of water is illustrated in Figs 4b and 5b. Not surprisingly, yellowing only becomes significant at temperatures in excess of 75°C. At moderate temperatures there is a slight decrease in yellowness which presumably occurs as a result of a bleaching effect arising from the removal of coloured material which was not removed in the cold water phase of the fibre purification.

From Figs 6b and 7b it is apparent that strong acid conditions cause significant yellowing only after prolonged time of immersion and then only at the boil. Mohair is affected to a significantly greater extent than the wool. Although acid conditions of this strength are not often employed in dyeing, the dyer would be well advised to limit the time of boiling as far as possible or consider dyeing below the boil as recommended by Strydom⁴.

The effects of weak alkaline conditions on yellowness are shown in Figs 8b and 9b. At low temperatures, even a period of exposure of two hours does not result in excessive yellowing of either the mohair or wool. Temperature appears the critical factor and above 50°C the tendency to yellow increases markedly, both fibres being equally affected.

Hydrogen peroxide under both acidic and alkaline conditions exhibits a bleaching action before inducing an increase in yellowness. At the lower temperature of 50°C the mohair shows no sign of yellowing after 16 hours but the wool begins to increase in yellowness after only 8 to 12 hours. At the higher temperature both fibres behave similarly under alkaline conditions. After the initial bleaching action yellowness begins to increase after 8 hours and rises sharply. Under acidic conditions, higher temperatures result in the mohair yellowing rapidly after only a short bleaching period whereas the wool undergoes a prolonged bleaching period before yellowing very rapidly. The results are shown in Figs 10b and 11b.

C. Mass Loss:

The major conclusion arising from the percentage mass loss figures is that mohair suffers a greater loss than wool under any given set of wet conditions. Typical results are illustrated in Figs 12a and 12b which show the effects of treatments at different pH values. It will be seen that the ratio of respective masses lost is about 1,5 : 1.

SUMMARY AND CONCLUSIONS

From an overall viewpoint it is not possible to conclude that mohair is more or less modified than the wool since trends indicated by one parameter do

not necessarily correlate with those of another. It is apparent that mohair, like other keratin fibres, is particularly temperature sensitive and, to a lesser extent, time sensitive.

With respect to the yellowing of the fibre, mohair would appear to be only slightly more susceptible than a comparable wool fibre. Furthermore, unless extreme conditions, particularly those of high temperature, are employed, the yellowing associated with most common processing conditions should not be a problem. The only possible exception is dyeing.

The similarity in yellowing behaviour between the two fibres is not entirely surprising. The amino acid compositions of mohair and wool have been shown to be nearly identical¹² and yellowing has shown to be due to amino acid modification¹³.

The greater mass losses associated with the wet treatment of mohair compared to that of wool may well stem from its supposed greater ortho-cortical content which makes for easier penetration of attacking species and the subsequent release of degraded material.

The study of the changes in urea-bisulphite solubility suggest that mohair is, in general, modified to a lesser extent than wool under mild conditions but that this trend is gradually reversed as conditions become more severe. As with yellowing and mass loss, temperature is the most significant parameter. It has already been suggested that the urea-bisulphite solubility behaviour of the two fibres may be a consequence of their respective ortho-cortical contents.

Thus far no mention has been made on the possible influence which the cuticular layers may have upon the effects of wet processing. The nature of the cuticle in general and, more particularly, the epicuticle, is of prime importance to protein fibres because, being the outermost layer, it must have a considerable influence on the effects of the various agencies which come into contact with the fibre. For example, the greater mass losses associated with mohair may arise from cortical differences or they may well be influenced by the stability and porosity of the cuticle. It is known¹⁴ that mohair has a radial distribution of ortho- and para-cortical material and thus differs from wool.

It is envisaged, therefore, that an extension to this work will be carried out in order to determine further information on the morphology of mohair.

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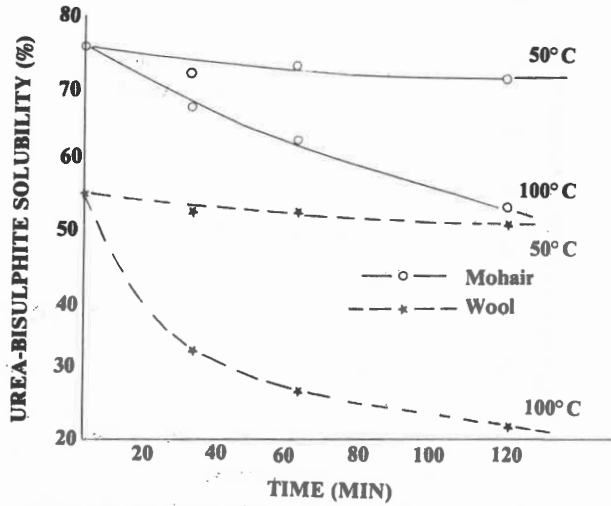


Fig. 4a Effect of time of immersion in water on the urea-bisulphite solubility of mohair and wool

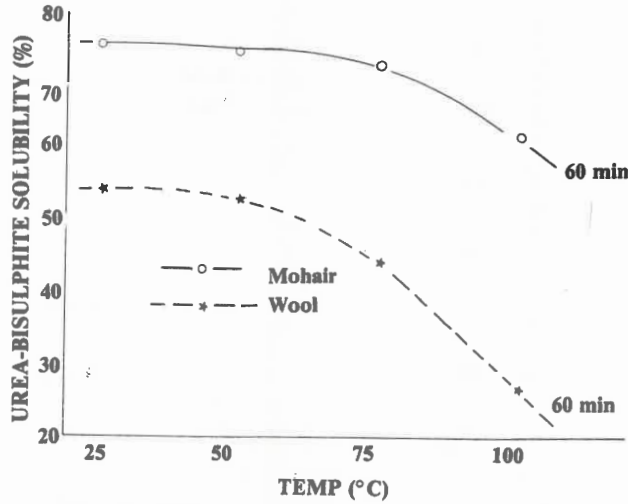


Fig. 5a Effect of water temperature on the urea-bisulphite solubility of mohair and wool

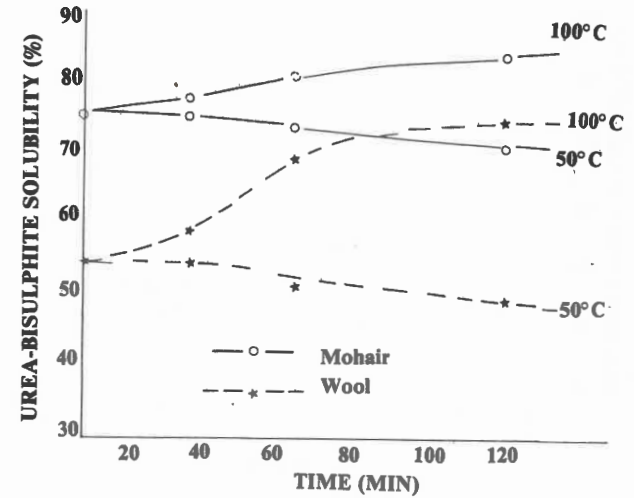


Fig. 6a Effect of time of immersion in strong acid solutions on the urea-bisulphite solubility of mohair and wool

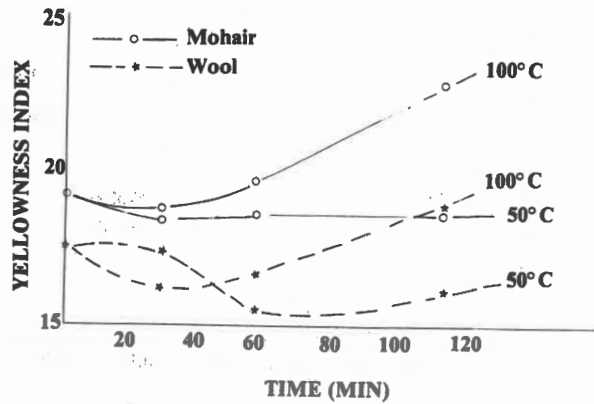


Fig. 4b Effect of time of immersion in water on the yellowing of mohair and wool

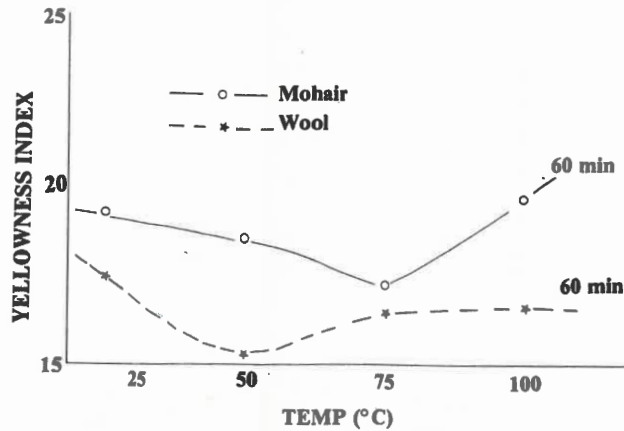


Fig. 5b Effect of temperature of water on the yellowing of mohair and wool

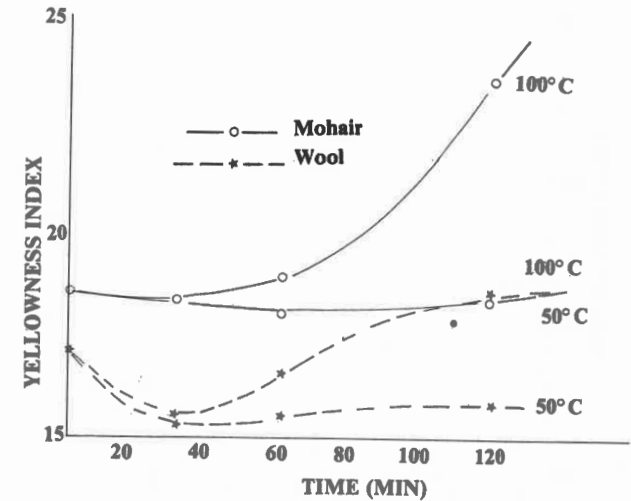


Fig. 6b Effect of time of immersion in strong acid solutions on the yellowing of mohair and wool

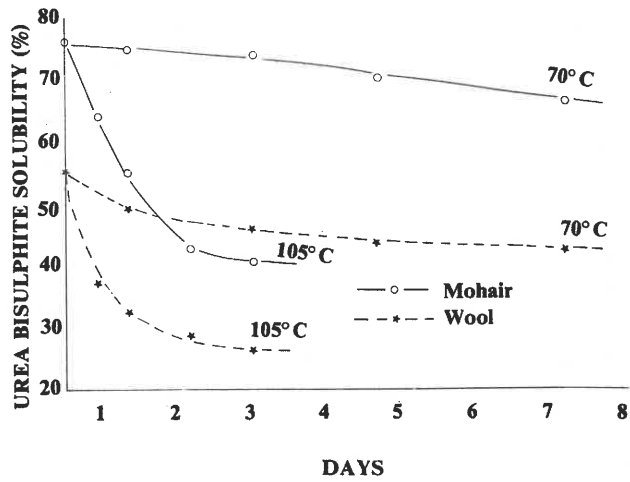


Fig. 1a Effect of dry heat on the urea-bisulphite solubility of wool and mohair

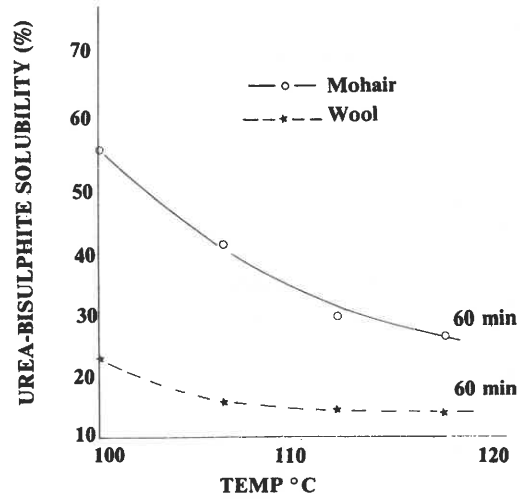


Fig. 2a Effect of steam temperature on the urea-bisulphite solubility of mohair and wool

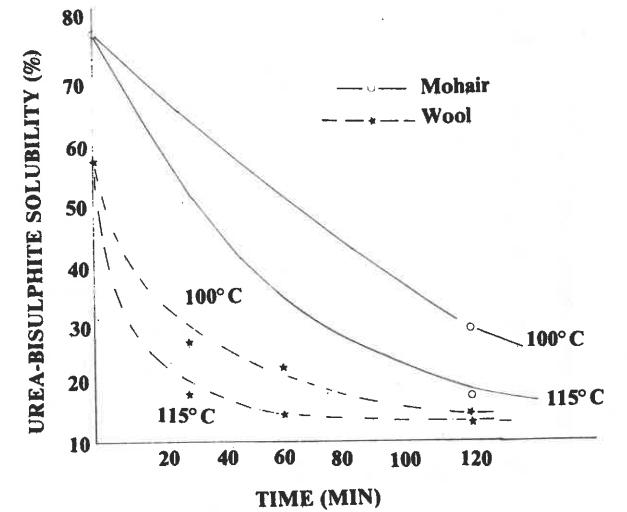


Fig. 3a Effect of steaming time on the urea-bisulphite solubility of wool and mohair

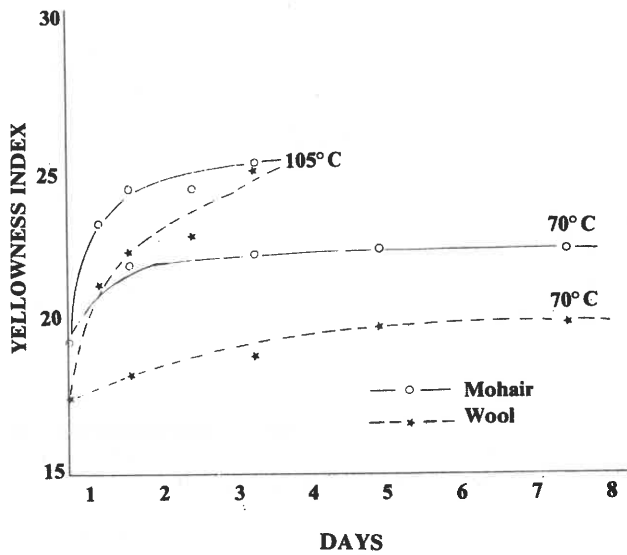


Fig. 1b Effect of dry heat on the yellowing of wool and mohair

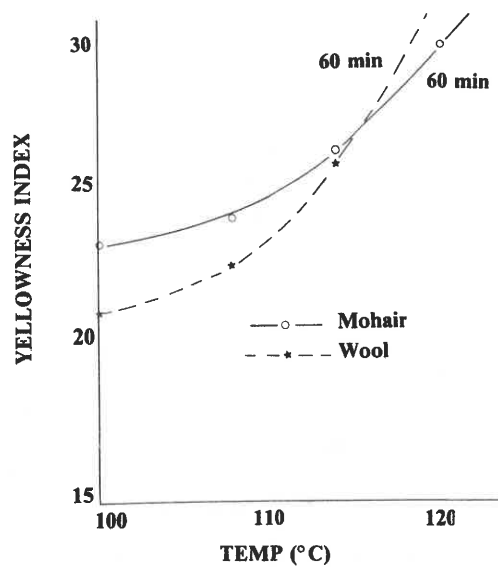


Fig. 2b Effect of steam temperature on the yellowness of mohair and wool

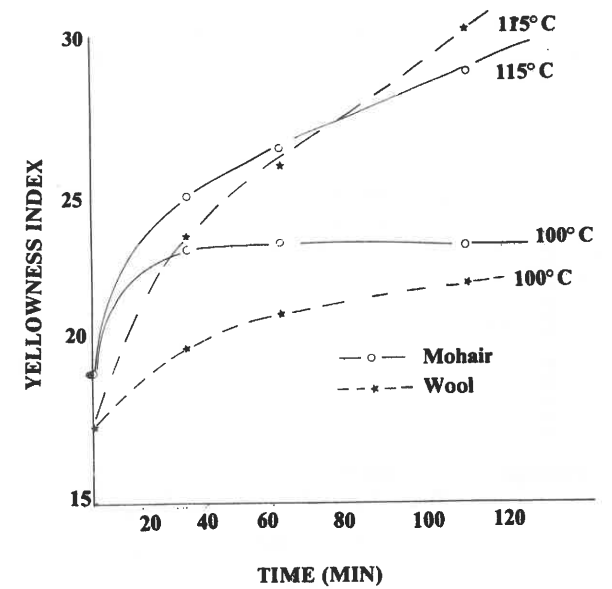


Fig. 3b Effect of steaming time on the yellowness of wool and mohair

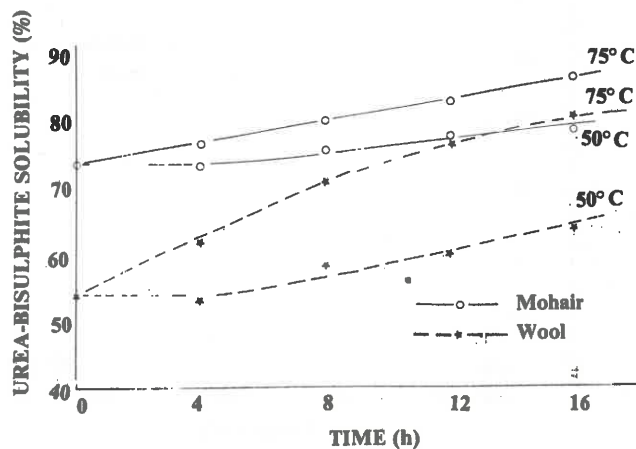


Fig. 10a Effect of time of immersion in 2 vol. acidic hydrogen peroxide on the urea-bisulphite solubility of mohair and wool

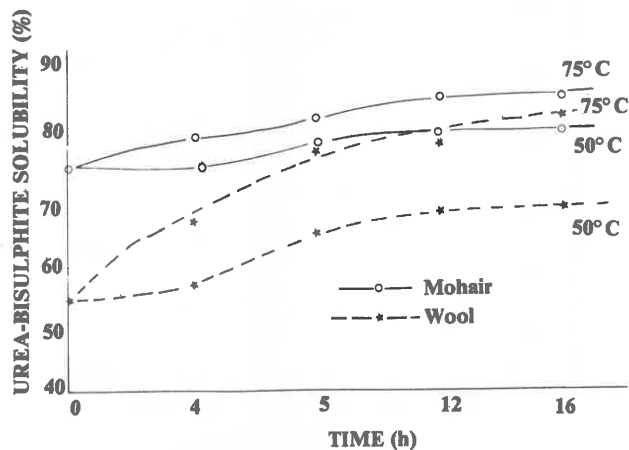


Fig. 11a Effect of time of immersion in 2 vol. alkaline hydrogen peroxide on the urea-bisulphite solubility of mohair and wool

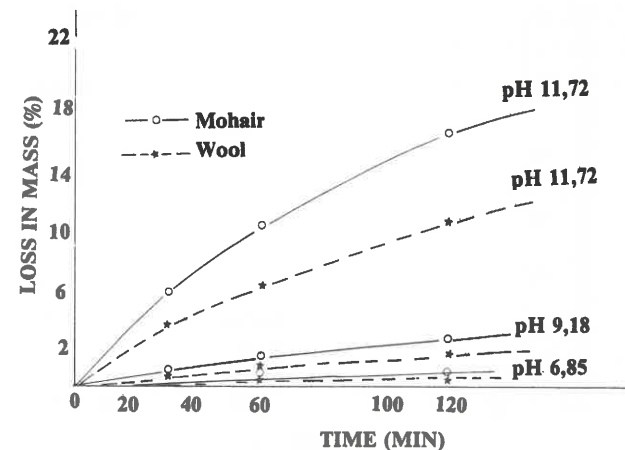


Fig. 12a Effect of time of aqueous treatment at the boil at various pH values on the mass loss suffered by mohair and wool

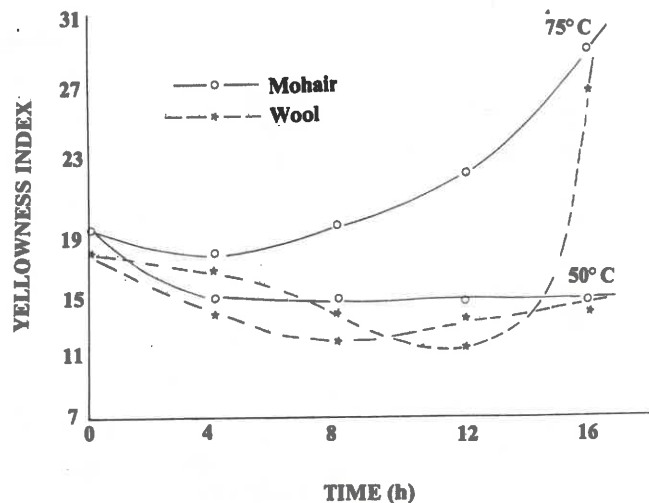


Fig. 10b Effect of time of immersion in 2 vol. acidic hydrogen peroxide on the yellowing of mohair and wool

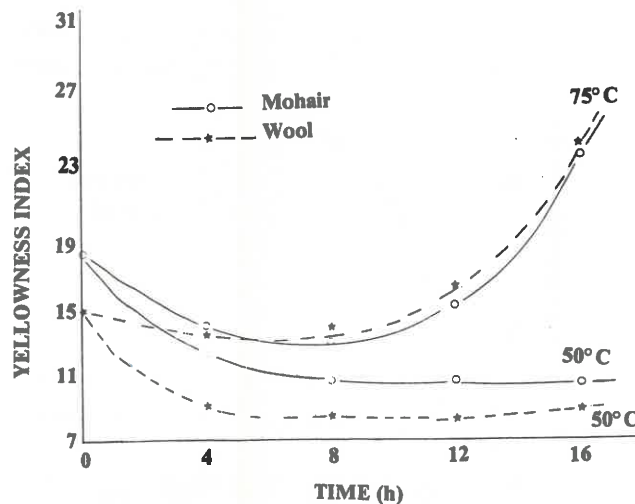


Fig. 11b Effect of time of immersion in 2 vol. alkaline hydrogen peroxide on the yellowing of mohair and wool

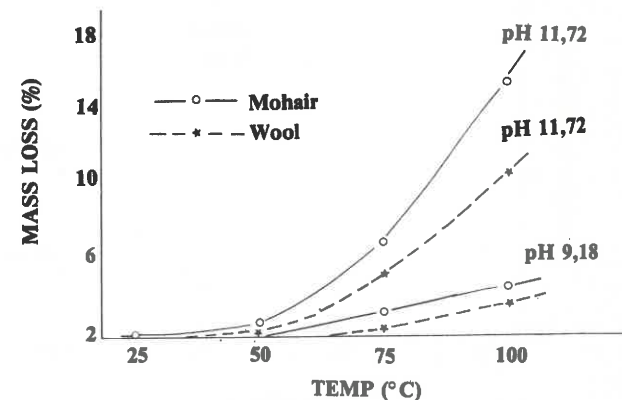


Fig. 12b Effect of temperature of a two hour aqueous treatment at various pH values on the mass loss suffered by mohair and wool

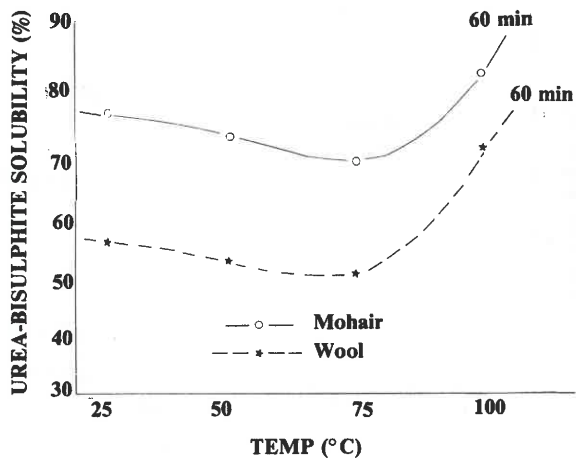


Fig. 7a Effect of temperature of strong acid solutions on the urea-bisulphite solubility of mohair and wool

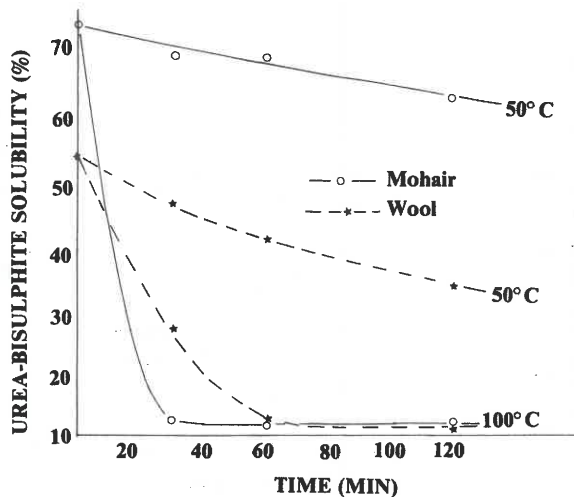


Fig. 8a Effect of time of immersion in weak alkaline solutions on the urea-bisulphite solubility of mohair and wool

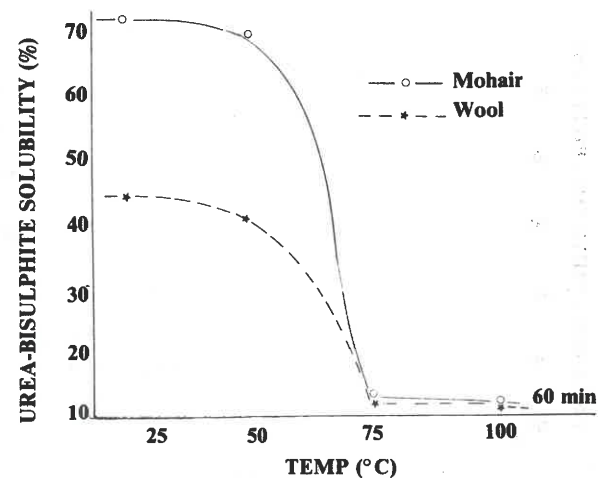


Fig. 9a Effect of temperature of weak alkaline solutions on the urea-bisulphite solubility of mohair and wool

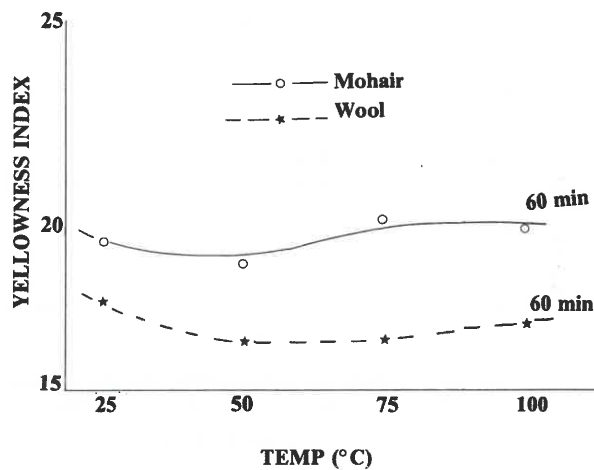


Fig. 7b Effect of temperature of strong acid solutions on the yellowing of mohair and wool

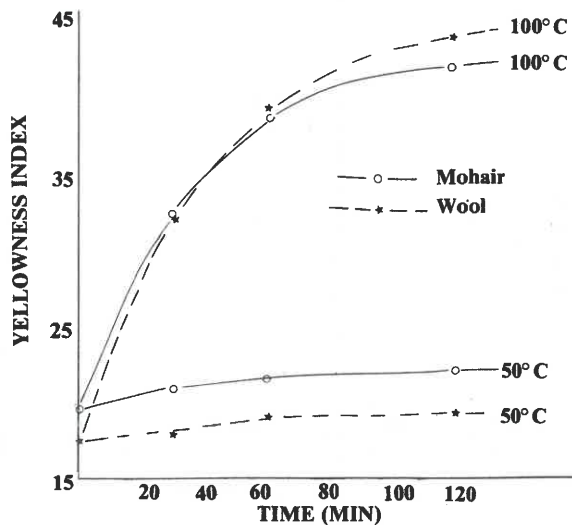


Fig. 8b Effect of time of immersion in weak alkaline solutions on the yellowness of mohair and wool

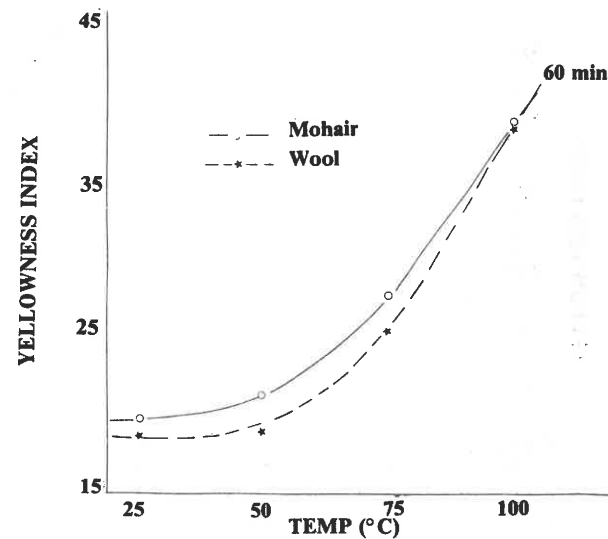


Fig. 9b Effect of temperature of weak alkaline solutions on the yellowing of mohair and wool

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