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Trace metals in wool fibre increase the production of hydroxyl radicals and yellowing in photo-irradiated wool

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SUMMARY

The accepted mechanism responsible for photoyellowing of wool involves the production of hydroxyl radicals (Millington 2006). In biological systems, bound metals, particularly iron and copper, can catalyse the production of hydroxyl radicals, which damage proteins, lipids and carbohydrates (Stadtman 1990). We hypothesise that trace metals in wool influence hydroxyl radical production that occurs when wool is exposed to sunlight.

To investigate this, undyed wool fabric was doped with 0.2 mM copper and iron solutions. Hydroxyl radical production after exposure to UVA light (366 nm) was assayed by immersing fabrics in a solution of terephthalic acid (TA), which reacts specifically with hydroxyl radicals to form the fluorescent hydroxyterephthalic acid (HTA) (λ_{ex} = 315 nm, λ_{em} = 425 nm). The assay was repeated with the addition of deferoxamine mesylate (DEF), which chelates iron and copper, rendering them inactive as catalysts for hydroxyl radical production. Photoyellowing of fabrics was determined by measuring the yellowness (Y–Z) before and after irradiation with UVB light (280–320 nm), which induces levels of oxidation similar to that produced by prolonged exposure to UVA. Samples were irradiated while wet to increase the rate of photoyellowing and to enable the redox reactions that occur in metal-catalysed oxidation which require an aqueous medium.

The production of hydroxyl radicals increased significantly in iron-doped wool and increased marginally in copper-doped wool, whereas the addition of DEF to the TA solution decreased the production of hydroxyl radicals in all fabrics (Fig. 1). There was no difference between the initial yellowness of the fabrics (mean Y–Z = 8.6, s.d. = 0.7). However, after irradiation, copper-doped fabric was significantly yellower than untreated and iron-doped fabric (Y–Z was 16.0 for copper, 13.4 when untreated and 13.7 for iron).

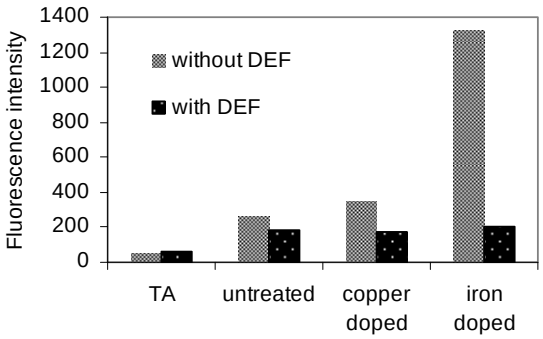

Fig 1. Fluorescence intensity at 425 nm of HTA, with and without DEF, after irradiation at 315 nm.

The higher level of photoyellowing for copper-doped wool may be that copper binding sites on proteins are adjacent to high concentrations of tryptophan or tyrosine residues, which form yellow products in irradiated wool (Dyer *et al*. 2006) whereas photoyellowing catalysed by iron, which produces more hydroxyl radicals than copper, is far more random. The influence of intrinsic metals on the extent of damage and yellowing during exposure to light may only be important in the fibre tips, which receive the maximum dose of sunlight and have higher metal content than the remainder of the fibre.

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