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Influence of the content of impurities and greasy on the results of heat resistance and hair cover dielectricity on the basis of wool from Huacaya alpaca and Racka sheep

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Abstract: *Influence of the content of impurities and grease on the results of heat resistance and hair cover dielectricity on the basis of wool from Huacaya alpaca and Racka sheep.* In recent years, the test method has become more and more popular by defining the electrical characteristics of various materials. The test is based on the difference in characteristic of the material in the electromagnetic field, which is described by the level of resistance or dielectric properties of the test material. The use of phenomena related to current flow and resistance makes it possible to evaluate the material being tested. Determination of the material quality by this method shows differences at molecular level, which makes it more accurate than in the case of traditional methods. The study investigated the effect of impurities and grease content on the results of heat resistance and dielectricity on hair cover on the basis of wool from Huacaya alpaca and Hungarian's Racka sheep. Studies have shown that washed wool has a better dielectric strength than greasy wool, as it has a higher resistance ($P < 0.05$). Wool from the Racka sheep contained more organic, organic matter and grease than alpaca wool, so the heat insulation of sheep was higher than in alpaca. Research has also shown that greasy matter together with non-organic and organic influences the results of electric characteristics testing, reducing wool resistance of the tested species. Wool wash affected the level of heat resistance of sheep wool and alpaca wool ($P < 0.05$). To conclude, washed wool is a better dielectric, which has a more positive effect on the skin coatings of people wearing clothes. However, wool washing causes a decrease in the thermal insulation of the wool.

Key words: impedance, heat resistance, dielectic, wool, Huacaya alpaca, Racka sheep

INTRODUCTION

In recent years, natural sciences have also used, in addition to traditional methods, the study of electrical characteristics, to determine quality and changes in materials. The method of testing the material using electrical characteristics has found its application in determining the quality characteristics, e.g. in microbiology (impedantoetry) or meat quality testing (penetrability). The test is based on the difference in characteristic of the material in the electromagnetic field, which is described by the level of resistance or dielectric properties of the test material.

Dielectric properties of materials are the result of low conductivity or low mobility of electric charges, as well as both factors simultaneously. Impedance means the total resistance of the material (passive and active) associated with a measure of resistance to which the material resists the flow of electric current. The use of phenomena related to current flow and resistance makes it possible to evaluate the test material (Jha et al. 2011, Yousefi et al. 2014). Determination of the material quality in this way shows differences at molecular level, which makes it more accurate than in the case of traditional methods (Samouëlian et al. 2005, Jha et al. 2011, Bancalari et al. 2016).

Changes in electrical and dielectric properties are influenced by factors such as water, temperature, frequency and intensity of electromagnetic field, thickness of the material layer and duration of exposure to electromagnetic fields. It is also important that the test be performed under constant environmental conditions, i.e. with constant humidity and temperature of the room in which it is performed (Jha et al. 2011, Samovelian et al. 2005).

Apart from soils, food and agricultural products, studies were carried out on the electrical characteristics of the hair cover of animals – wool. They were made in the 1970s. These tests have shown that wool in electromagnetic fields exhibits dielectric properties. It owes its properties to the waxy layer on the hair surface. Physico-chemical changes under the influence of water content were also demonstrated, where an increase in dielectric dispersion (dependence of electrical permeability on frequency) with water content in hair was demonstrated (Algie and Gamble 1973).

The study investigated the effect of non-organic, organic and grease content on the results of heat protection and dielectricity on hair cover on the basis of wool from Huacaya alpaca and Hungarian Racka sheep.

MATERIALS AND METHODS

Test material

Wool samples came from the Zoological Garden in Wroclaw from the alpaca Huacaya and the Racka sheep. The animal crossword took place in May with a full year growth of the wool (the samples were taken from left part of shoulder). For measurements of electrical characteristics and heat resistance, greasy wool samples were taken from five animals from each breed and uniform in weight.

The wool after the first stage of the study of heat resistance and electrical properties was washed twice with the use of soap composed of: Sodium Tallowate, Sodium Cocoate, Sodium Chloride, Aqua, Glycerin, Tetrasodium Etidronate, Sodium Hydroxide and then dried. Next the sample was dried in laboratory, in place without natural light from two days at 30°C.

The test weight before washing was 0.35g (+/–0.02g) and 0.52g (+/–0.015g) during the measurement.

Heat resistance test

The study was conducted with the use of Matest's Apparatus for evaluation of materials exposed to heat radiation, heat protection (*WPC*) treatment. Measurements were repeated twice.

The heat transfer coefficient (*WPC*) is calculated from the formula:

$$(WPC = GSC_p/GSC_o)$$

where:
WPC – thermal resistance
GSC_p– the density of the thermal flux passing through the test [kW/m^2]

GSC_0 – the density of the thermal flux to be tested [kW/m^2]

$$\left(GCS_p \, \frac{M \cdot Cp \cdot R_1}{A \cdot a} \right)$$

$$GCS_0 \, \frac{M \cdot Cp \cdot R_2}{A \cdot a}$$

where:
M – mass of the aluminum calorimeter sample: 7.16 g;
C_p – heat specific aluminum: 900 J·kg/ /°C^{-1};
A – surface area of calorimeter: 0.00049 m^2
α – absorption coefficient of the blackened calorimeter surface area: 0.95;
R_1 – rate of increase of calorimeter temperature in the linear part of the graph (for calorimeter with sample) [°C/s];
R_2 – rate of calorimeter temperature increase in the linear part of the graph (for empty calorimeter) [°C/s].

Tests of electrical characteristics

The samples were tested using the Atlas Solich High Impedance Analyser Atlas 0441. The samples were placed between the copper electrodes in a 3.9 mm thick chamber with an inner diameter of 38 mm, made of plastic. Measurements were taken at a constant temperature of 25°C and 70% humidity and repeated twice.

Development of results

The results were statistica ver. 13.1 Normal distribution of results was evaluated by the Shapiro-Wilk test. In the case of normal distribution, differences between groups were examined using the t-student test for independent samples. If decomposition was not normal, the Wilcoxon test was used. Differences between groups were statistically significant when $P < 0.05$.

RESULTS AND DISCUSSION

The results of the analysis of the content of fat and non-organic and organic matter showed significant differences before and after suppression (Table 1). The average weight of alpaca wool before washing was 0.348 g, while its weight after washing decreased to 0.3258 g, i.e. the

TABLE 1. Difference between washed and greasy wool

Impedance [Ω]	Washed wool	*SD*	Greasy wool	*SD*	*p*-value
Alpaca	5685965.6^{A}	1863548.61	48163179.0^{B}	1547623.81	0.000002
Racka sheep	15348254.1^{A}	523497.06	9982139.4^{B}	26830.57	0.000001
Content of sebum and impuritie	greasy wol	*SD*	washed wool	*SD*	*p*-value
Alpaca	0.35^{a}	0.03	0.33^{b}	0.01	0.0253
Racka sheep	0.34^{a}	0.04	0.25^{b}	0.04	0.0014
Heat resistance	washed wool	SD	greasy wool	SD	*p*-value
Alpaca	0.76^{a}	0.02	1.17^{b}	0.23	0.0133
Racka sheep	0.82^{A}	0.18	1.11^{B}	0.14	0.000084

content of greasy matter and impurities was about 0.022 g in the tested samples, while sheep wool contained about 0.092 g (respectively: 6.32% and 26.59%). When comparing the differences between the different species examined, it was found that wool from Racka sheep contained more non organic and organic matter and fat than alpaca wool.

In order to detect the influence of impurities and grease on the dielectric properties of wool, an electric characteristics test was carried out. It works on the principle of impedance, which makes it possible to determine changes at molecular level, because impedance is a generalization of electrical resistance characterizing this relationship in direct current circuits. Impedance is a composite size, defined by Ω (Nelson 2008, Bancalari et al. 2016). The results of the own study showed significant differences between the impedance of washed and greasy wool (Table 1). Impedance results were characterized by significant leaps at the current flow frequency in the range from 10 to about 6400 Hz. On the other hand, after exceeding 6400 Hz, rope declines occurred in both cases (Figs 1, 2).

Significant pitch of values in both wet and greasy alpaca wool can be observed at the current flow frequencies of 10, 20 and 40 Hz. (Fig. 1). In the case of sheep wool (Fig. 2), significant resistance peaks occurred at current flow frequencies of 10 and 20 Hz and 98 to 260 Hz. However, for most of the jumps, the washed wool of both species showed higher values than greasy wool.

Washed wool of both animal species was characterized by higher resistance than greasy wool. Impedance of alpaca wool increased after washing by approximately 8.7 MΩ on average, and that of sheep wool by approximately 5.37 MΩ on average, which also indicates an increase in the level of dielectricity of the wool studied. This shows the relation-

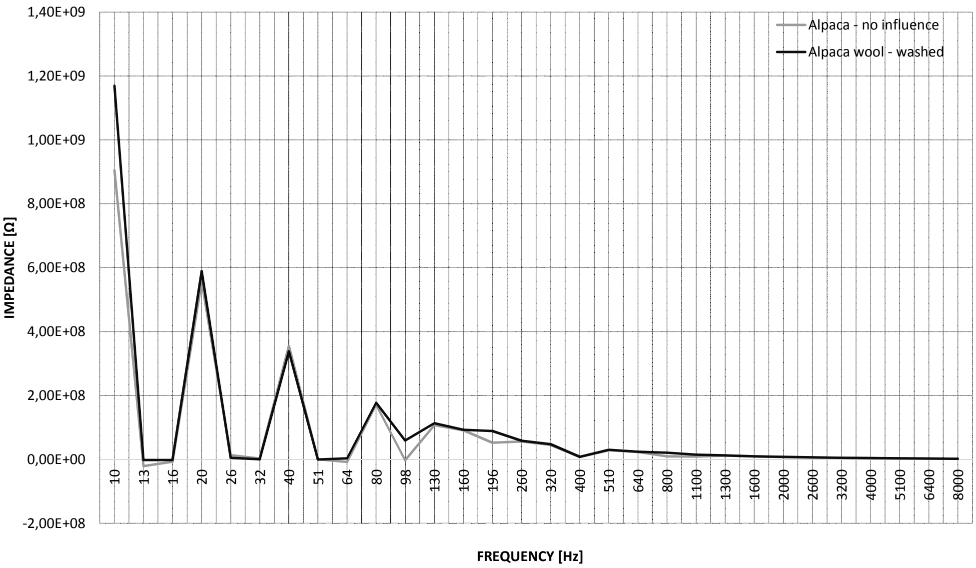

FIGURE 1. Impedance of alpaca wool

FIGURE 2. Impedance of Racka sheep wool

ship between the non-organic and organic matter and grease content of the fibre dielectric properties.

The additional investigations of heat resistance showed the difference between wool washed and greasy in alpaca and sheep (Table 1). Washed wool of the examined species was characterized by significantly lower heat protection ($P < 0.05$) than in the case of greasy wool. The differences received have also shown that they are greater for wool from Racka sheep than from alpaca. This is also covered by the amount of impurities and grease removed in the wool. In addition, comparing the results of heat resistance and impedance, it can be concluded that the level of fiber dielectricity increases with its decrease (Fig. 3).

Fat and non-organic and organic matter are essential components of wool. The composition of the greasy depends on the species and breed origin, age, diet and climatic and geological conditions. Fat and sweat are intended to protect both hair and skin surfaces (Cholewińska et al. 2016).

The fat and sweat layer is also important as a substance that alters the physical properties of fibres because of its composition. The fat layer in about 35% is made up of esters of higher fatty and waxic acids and aliphatic alcohols, about 25% are free fatty acids and in about 25% sterols and a small amount of hydroxylic acids and salts (Jover et al. 2002). However, 90% of sweat consists of water and the remaining 10% consists of organic salts and acids (Jaber et al. 2012). Results of our own research showed that the greater amount of fat and impurities is characteristic of sheep wool (26.59%) compared to alpaca (6.32%). The fat, together with its afterwards and non-organic and organic matter, could reduce resistance due to the content of mineral

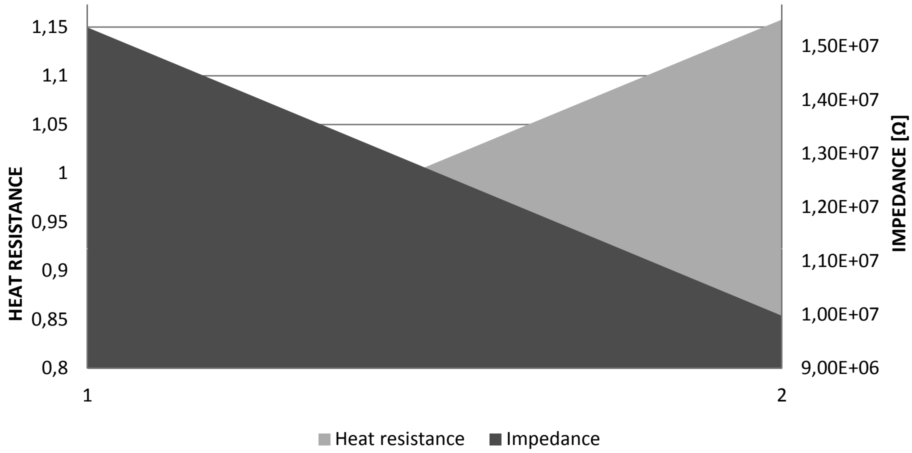

FIGURE 3. Changes between impedance and heat resistance

salts and dusts, which increased the conductivity of the fibre.

The results of the impedance test showed a significant influence of impurities on its resistance and thus dielectricity. Washed wool had higher resistance, which was probably caused by removed impurities and grease. Another feature influencing the results of impedance, i.e. resistance, is the inclusion of wool in the dielectric, i.e. a material in which the current is poorly conductive, which may be the result of low concentration or low mobility of electric charges or both factors simultaneously (Łuczycka 2009, Pastewski and Galla 2012). The properties of wool as a dielectric were included in the Callahan and Kornberg (1993) patents. It has been shown that wool fabrics have an electro-anaesthetic effect on the human body because wool acts as a capacitor, but the patent captures greasy wool which, according to own research, is characterized by a lower resistance and produces a positive charge, as reported by Pastewski and Galla (2012). In turn, the better the properties of the dielectric, the better the fabric works as a capacitor (Callahan and Kornberg 1993), so that the washed wool turns out to be a better capacitor than greasy wool.

Probably wool without a layer of fat matter gains better properties related to the characteristics of the dielectric by washing, which appears in the study of its own impedance. However, heat protection is reduced. Taking into account that fat matter is a kind of protective barrier for hair, including thermal barier (Cholewińska et al. 2016), its washing also results in a decrease of its thermal insulation, which was also demonstrated in the study of wool heat resistance.

However, testing of electrical characteristics on fibres is in the initial phase of research. In order to finally determine the influence of various factors on the results obtained, further investigations should be carried out. Determining differences and changes in fibres by means of electrical characteristics may in the future speed up the evaluation of fibre quality and changes in fibre quality, e.g. due to abnormal diet or diseases of animals from which wool is sourced.

CONCLUSIONS

1. Washed wool has got a better dielectric strength than greasy wool because it has a higher resistance ($P < 0.05$).
2. The electrical characteristics test showed changes in wool caused by washing as well as the heat protection test ($P > 0.05$). Where the washed wool has higher level of impedance and resistance then greasy wool.
3. Fat and non-organic and organic matter influence the results of electric characteristics testing, reducing wool resistance of the tested species.
4. The sheep's wool of Racka sheep contained more non organic and organic and fat matter than alpaca wool, so the heat loss in sheep was higher than in alpaca.

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Streszczenie: *Wpływ zawartości zanieczyszczeń i tłuszczopotu na wyniki ciepłochronności i dielektryczność włosa na podstawie wełny z alpaki huacaya i owcy rackiej.* W ostatnich latach metoda badania materiałów za pomocą cech elektrycznych stała się bardziej popularna, dzięki wysokiej czułości badań. Badanie tego typu wykazuje zmiany na poziomie molekularnym, opiera się ono na różnicy zachowań materiału w polu elektrycznym, opisując jego poziom oporu lub właściwości dielektryczne. Metoda ta jest znacznie dokładniejsza niż metody tradycyjne. Celem pracy było określenie wpływu zanieczyszczeń i tłuszczopotu na oporność i ciepłochronność wełny owcy rackiej i alpak huacaya. Badania wykazały, że wełna prana ma wyższy poziom oporności niż wełna potna (P < 0,05). Wełna potna owcy rackiej charakteryzowała się wyższym poziomem ciepłochronności niż wełna alpak, ze względu na wyższą zawartość tłuszczopotu i zanieczyszczeń w wełnie. Badania wykazały również, że tłuszczopot wraz z zanieczyszczeniami wpływa na wyniki testów właściwości elektrycznych, zmniejszając oporność w porównaniu do wełny pranej. Pranie wełny wpłynęło na poziom ciepłochronności wełny owczej oraz wełny alpak (P < 0,05). Podsumowując, prana wełna jest lepszym dielektrykiem, przez co ma bardziej pozytywny wpływ na powłoki skórne osób noszących ubrania. Jednak pranie wełną powoduje obniżenie ciepłochronności wełny zarówno alpaki, jak i owcy rackiej.

Słowa kluczowe: impedencja, ciepłochronność, wełna, alpaka huacaya, owca racka

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