Investigation of natural levels of copper in fungi as protection in wearable textiles for electrically sensitive individuals.

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Linda Row is a sustainable clothing designer, founder of Clothworks in 1997 and Boutique Ethique in 2006. She is currently developing a smart textile, to neutralize harmful electromagnetic frequencies for the electro-sensitive population, at Manchester Metropolitan University.

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Electro-smog from technologies such as Wi-Fi and mobile phones are a ubiquitous part of modern-day living and the incidence of electro hypersensitivity is rising. The growing number of individuals who are sensitive to electromagnetic fields is the forewarning of an emergent dystopia, from symptoms including skin rashes, heart palpitations and headaches to brain fog and attention deficit disorder. Efforts to address such detrimental concerns have become crucial in all sectors including the wearable technology in the fashion industry. To establish a mechanism for neutralizing the potentially harmful effects of manmade radiation, a pilot study was undertaken by this study to hypothesise and test that the hyper-accumulation of copper, in some species of fungi, could be extracted and used as a protective element for the electrically sensitive population in wearable textiles. Three samples of silk, pre-mordanted with alum or pomegranate skins, were treated with an extract of either Shiitake (Lentinula edodes), Blewit (Lepista nuda) or Button mushrooms (Agaricus bisporus). Applied kinesiology (Manual muscle testing) was further employed to determine the change in muscle strength of participants with the treated silk. The results showed that there was a significant difference between muscle strength and the fungi treated silk during exposure to cell phone radiation. Blewit and alum produced a better muscle response, warranting further experimental work with this variant. The study combines traditional and innovative methods of neutralizing electromagnetic fields.

Keywords: non-ionising radiation; electro-hypersensitivity; hyper-accumulation; copper; Wi-Fi; mobile phones, wearable-textiles.

Introduction

Exposure levels to background radiation have increased dramatically during the past twenty years (Carpenter and Sage 2012). Technologies such as WiFi and mobile phones, used for communication and data transmission, have associated health impacts and the involuntary exposure to non-ionizing (NI-EMR) is a cause for global concern. NI-EMR in the radio frequency (RF) 3kHz – 300 GHz bands and extremely low frequency (ELF) 3 Hz – 30Hz bands, are used as carrier waves and for data transmission. More than 20,000 studies have been conducted since 2007, to investigate the biological interface with manmade or 'anthropogenic' frequencies. Some biological effects from ionizing radiation are said to be the same as non-ionizing, for example, the inducement of free radicals (Bevington 2015). These effects occur faster in ionizing radiation but have related outcomes.

Since the introduction of electricity into the home in the early 19th Century, there have been claims that some individuals are sensitive to anthropogenic frequencies (Milham 2009). The 1980's saw computers installed into the work/ home environment, causing an increase in this condition, attributed to radiation from monitors. Since this time new technologies have increased exponentially and between 4% and 10% of the population claim to be electro sensitive, dependent on the location (Blythe 2016). Those individuals with extreme EHS are unable to travel on public transport, go to shopping centres or attend schools and universities. Sweden was first to recognize EHS as a chronic disability and many other countries are enforcing stricter regulations around the use of technologies for children.

As a result of this increasing exposure to anthropogenic fields, products have been developed, ranging from portable devices to items of clothing that incorporate conductive fibers into the yarn. LessEMF.com (n.d :online) provide shielding fabrics that use silver, aluminium or steel in their fiber composition, for the production of bedding, clothing and tents that surround the bed.

Mining for minerals have had negative impacts on the environment, from contamination of ground water and soil erosion to the amount of energy used by smelters (Young and Ayres 1992). For such reason a unique alternative was sought for the present study, in the form of hyper-accumulating species of fungi that have large amounts of naturally occurring copper.

Mushrooms

Research has been conducted since the 1970's to screen mushroom fruiting bodies for toxic accumulations of heavy metals (Kalac and Suoboda 1999). It has been established as a result of environmental disasters that mushrooms are very successful bio-accumulators and some species are hyper-accumulators of heavy metals such as cadmium, mercury, lead and copper also cesium. These are used as bio-indicators of environmental toxins. Wild mushrooms are consumed in many European countries and following the Chernobyl reactor disaster of 1986, levels of cesium in edible mushrooms where identified from the fallout in Germany, Italy, Sweden, Bulgaria and Moscow (Stamets 2005).

Concentrations of metals in fungi are "species dependent". Stamets (2005, 105) suggests that the ability for mushrooms to selectively take up metals could be a measure employed to clean up polluted sites, "in effect the toxins move into a portable cellular vessel". In addition, take-up varies according to whether the substrate is wild or cultivated. The age of mycelia (the web of single cells that spread through the soil) is significant in the stage of fructification, for example in Agarius Bisporus. Wild mushrooms may therefore contain greater quantities of metal ions, where mycelia have had time to become established and penetrate deep into the soil. Copper is accumulated in the fruiting body, not in the mycelium, however the greatest concentration is in the gills. Other metals have different uptake levels in both mycelia and fruiting body. Copper levels in mushrooms are higher than for those in plants (Kalac and Suoboda 1999, 277).

In this paper, a pilot study was undertaken to test the hypothesis that the hyper-accumulation of copper in selective species of fungi, could be used as protection for the electrically sensitive population in wearable textiles.

Materials and Method

Mordants

Metal mordants are polyvalent and can therefore form bonds with both a dye and a textile substrate (Baker, 1958); they form organic complexes from ionic interactions that are insoluble in water. For this study, alum was selected as a traditional mordant for silk, together with pomegranate skins, which are rich in tannins (Brunello, 1973).

Peace silk was selected, which is humanely cultivated, allowing the silkworm to emerge before the fiber is spun (Gardetti and Muthu, 2015). Silk has an affinity for natural dyes, most natural dyes are acidic and form bonds with protein fibers (Burch n.d: online). One meter of lightweight Peace Silk (weight 30g) was divided into three equal pieces and pre-mordanted with alum (15g of Alum and

8g of cream of tartar), pomegranate (8g dried pomegranate skins) and finally no mordant. These pieces were further divided into three and treated with solutions of fungi.

Fig.1; a) Shiitake (Lentinula edodes), b) Button Mushrooms (Agaricus biporus), Photography by Louis Kandukar, December 2018.

Three fungi were selected due to their high copper content: Shiitake (*Lentinula edodes*), Blewit (*Lepista nuda*) and Button Mushrooms (*Agaricus bisporus*); 5.16, 7.5 and 20.80 m/100g respectively. 5g of dried Blewit mushrooms were simmered in 50ml of water and 5ml white vinegar for 40 minutes, to extract the copper. This measure was repeated using 50g fresh button mushrooms and 5gms of dried shiitake mushrooms, to create three mushroom dye baths.

Treatment

The nine pieces of pre-mordanted silk were simmered separately in 10ml of each fungi solution, at 72○c for 30 mins. This resulted in nine treated samples of peace silk and one sample was created with no mordant and no treatment.

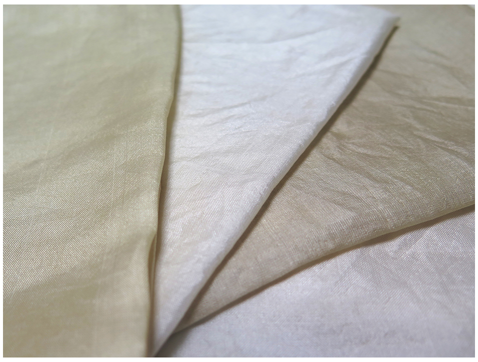

Figure 2: Peace silk samples   Figure 3: Peace silk and pomegranate

Photography by Louis Kandukar, December, 2017.

Kinesiology

Kinesiology as a diagnostic tool has roots in chiropractics and acupuncture, utilising the electrical pathways in the nervous system. Goodheart, who lectured in chiropractice, initiated the art of 'listening to the body' using the musculoskeletal system and established the technique of Applied Kinesiology (AK) in 1964. AK was derived from Manual Muscle Testing, first developed by Loett in 1912 (Schmitt and Cuthbert, 2012). The International College of Applied Kinesiology made the following definition of this technique:

> Manual muscle tests evaluate the ability of the nervous system to adapt the muscle to meet changing pressure of the examiner's test. An examiner exerts pressure on the muscle of the subject and the

subject is instructed to resist this force. The examiner applies an additional force and the ability of the subject to withstand this force determines whether the muscle is weak or strong

(Cuthbert and Goodheart 2007:3)".

This is referred to as " the breaktest". Kendall and Kendall (1952) rated these results as "facilitated" or "strong" compared to "inhibited" or "weak". It has been documented within the literature that "Physical imbalances produce secondary muscle dysfunction, specifically a muscle inhibition" (Lund et al. 1991).

It was proposed by Dyson (2012) that the pathway of electrical signals being conducted by the nervous system along the muscles might be altered in the presence of NI-EMR. For this study it was anticipated that with the addition of the treated samples of peace silk this pathway would be restored.

A sample of seven participants was chosen: three males and four females, age range from 22 to 65. Participant 'a', 'b' and 'c', self-diagnosed as slightly sensitive to EM fields, manifesting as digestive disorders and fatigue. The remaining participants ('d', 'e', 'f' and 'g') were not aware of any sensitivity. There were no outstanding health concerns amongst the participants and the sample excluded pregnant women and individuals with extreme sensitivity to NI-EMR. Manchester Metropolitan University ethics committee approved the study and informed consent was sought with all participants.

Method

A measurement was taken of ambient radiation present in the room, using the

Acousticon 2 meter. This measures radio waves from 200 MHz to 8GhZ and these sources of radiation were eliminated. The kinesiology practitioner made a preliminary arm muscle test, using resistance, to determine the strength of the participant. The observation was informal and a record of the strength or weakness of the arm muscle was recorded on a scale of 1-5,1: weak 5: strong, from a vertical position to a horizontal position.

A blinded experiment was performed by the kinesiologist for each of the seven participants. Participants were first tested separately with alum, pomegranate skins and peace silk, to determine if any allergies existed to these. The participants were then exposed to a cell phone and the strength of arm muscle was measured. This was followed by additional tests placing each of the nine treated samples and then the untreated sample, separately, on the shoulder of the participant. A record was maintained for each result and this was repeated for all seven participants three times.

Findings and discussion

The data is an interval scale, as ranking scale that was used in the study is from 1 - weak to 5- strong, since there were decimal data it is assumed that there is an order of value and differences between the values. The data was gathered on the same set of participants (a to g) with variant 10 and other variants 1 to 9. This could be assumed as paired data (before and after; where ‘before’ is with variant 10 and ‘after’ is with other variants 1 to 9).

Mushroom Variety →	1	2	3	4	5	6	7	8	9	10
Average Muscle strength	4.63	4.04	4.33	4.43	3.9	4.43	4.28	3.86	3.51	1.33
Standard deviation	-0.016	1.18	0.22	0.27	0.97	0.19	0.52	0.69	-0.53	0.46
Average of variants 1-9	4.16									
Standard deviation of variants from 1-9	± 1.4									

Table 1. Muscular response from tests, *ranging from 1 weak to 5 strong.*

Mushroom Variety: 1 Blewit and alum; 2 Blewit and pomegranate; 3 Blewit and no mordant; 4 Shiitake and alum; 5 Shiitake and pomegranate; 6 Shiitake and no mordant; 7 Button mushroom and alum; 8 Button mushroom and pomegranate; 9 Button mushroom and no mordant; 10 No mordant and no treatment

	Var 1 vs Var 10	2 vs 10	3 vs 10	4 vs 10	5 vs 10	6 vs 10	7 vs 10	8 vs 10	9 vs 10
Mean of differences	3.3	2.714	3	3.1	2.57	3.1	2.96	2.53	2.186
Standard deviation	0.913	1.65	1.389	1.140	1.52	1.05	1.085	1.372	1.403
Standard error	0.913	0.624	0.525	0.431	0.574	0.396	0.41	0.518	0.053
95% confidence interval	2.456 to 4.144	1.186 to 4.242	1.715 to 4.285	2.045 to 4.154	1.166 to 3.976	2.130 to 4.07	1.954 to 3.96	1.26 to 3.797	0.888 to 3.483
Degrees of freedom	6	6	6	6	6	6	6	6	6
t value	9.56	4.35	5.71	7.19	4.47	7.82	7.214	4.88	4.12
One sided P Two-sided P	0.0001 0.0001	0.0024 0.0048	0.0006 0.0012	0.0002 0.00.4	0.0021 0.0042	0.00001 0.0002	0.0002 0.0004	0.0014 0.0028	0.0031 0.0062
Power	94.7	94.7	99.15	99.85	99.92	99.92	99.85	97.46	92.7

Table 2: Summary of paired t-test

Interpretation of t-test:

Since one-sided and two-sided P value is <0.0001; we can reject the null hypothesis [H_0] and accept alternative hypothesis [H_1], that means the mean of var 1 and 10 are significantly different. The null hypothesis states that there are no differences between var 1 and 10, α-value is always 0.05. If P>0.05 we reject the null hypothesis. It is also important to note the mean of differences lies within 95% confidence interval values.

Based on the above statistical test it could be observed that for variants 1 to 9, the mean muscle response was significantly different to variant 10 (control). However, a closer look at the mean of differences between variants 1 to 10, it could be noted that variant 1, Blewit and alum, had a better muscle response compared to other variants 2 to 9. Hence, further work will be carried out using variant 1.

This pilot work demonstrated that the hyper-accumulation of copper in selective species of fungi (blewit and alum) could be used as protection for the electrically sensitive population in wearable textiles

Conclusion

The study has demonstrated that wearable textiles treated with fungi, may offer some benefits for the electrically sensitive population, as a novel and sustainable alternative to the shielding fabrics that are currently available. Within the creative context of fashion design, it proposes development of wearable fungi copper textile outfits that are not only aesthetically attractive, but also have the potential to protect and reduce the adverse effect of electromagnetic radiation.

Fig.4: Shirt made from peace silk, dyed with shiitake and button mushrooms, mordanted with pomegranate and iron as a colour modifier. Photography by Louis Kandukar, April, 2018.

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