CHAPTER FOUR

CONCLUSIONS AND FUTURE WORK

4.1 Conclusions

Not only natural dyeing techniques but the mere tradition of natural dyeing has almost been lost due to many reasons as discussed in section 1.4.2. Sir William Perkin or the synthetic dyes could not be blamed totally for the loss of this valuable tradition. Inadequacy of the actual chemical back up of the techniques, proper methodical experimentation of technology to suite the modern market competition, not to mention the poor dissemination of prevailing techniques were equally responsible for risking natural dyeing tradition. As a result, the development and adaptation of natural dyeing to the ever-changing requirements of modern dyehouses have been hindered, and a considerable gap exists separating the knowledge about natural dyes from the demands of commercial dyeing processes. But with the stringent environmental standards imposed by many countries in response to the increasing environmental pollution and, toxic and allergic reactions associated with synthetic dyes; a growing interest in the use of natural dyes in textile applications has arisen. With this revival, the necessity of scientific reasoning and incorporation of the new developments in technology to the traditional natural dyeing techniques has been understood. An attempt has been made by Bechtold et al to investigate the possibility of combining the natural dyeing techniques, which use mordants to the requirements of the modern dyehouses [49]. On the other hand another major draw back in bringing natural dyes to modern dyehouses is the difficulty in agricultural production large quantities of raw materials needed for dye extractions, without disturbing the ecological balance. This research study was launched after considering all these aspects, with the aim of rediscovering the Sri Lankan traditional natural dyeing techniques and indigenous dye producing plants, and to investigate into the possibility of introducing a new natural colouring source based on an indigenous plant resource, which is abundant as a waste material.

In fulfilling the first two requirements, a list of indigenous dye producing plants and detailed description of traditional Sri Lankan natural dyeing techniques with special reference to textiles is produced in section 3.1.1 and 1.6 respectively. The list of dye

producing plants that is presented here is only the documented dye producing plant species and is only a very minute amount of the actually available such plant sources in Sri Lanka. To accomplish the third requirement, black tea, which is abundantly wasted as tea dust in factories and brewed tea in domestic sources were selected through a thorough literature survey and experimentation.

Tea proved to be a good source of not only high amounts of dye intermediates (polyphenols) for natural dyes but also many other pigments that could be used as dye matter as well. Tea leaves were successful in using for extraction of polyphenols to be used for azo dye preparation. The extraction of polyphenols could be easily done in aqueous media, which were slightly alkaline (around pH 8). Approximately 64% and 34% of polyphenols out of the available polyphenols in black tea leaves were extracted from unused and brewed black tea leaves using the method developed in this study. The extractability of polyphenols showed higher values in alkaline solutions but should be further tested to come to a conclusion about the significance of extractability in alkaline media. The glycoside bonds in polyphenolglycosides, which are a common form of the polyphenols in tea can be hydrolysed to obtain more of free polyphenols. In this way the amount of water soluble polyphenols in tea can be increased and hence the yield of extractable polyphenols can be increased. Hydrolysis can be carried out by boiling tea leaves in the presence of an acid.

Out of the types of dyeing methods tested, namely mordant, vat and azo, tea provides a promising base for in-situ azo dyes on cotton especially when the coupling component is exhausted as a cation in acidic media. The exhaustion of coupling component in the alkaline medium also produced good shade on cotton although they were not deep in shade as were in the acidic media.

The extracted polyphenols were successfully used as in-situ azo dyes on cotton with moderate to good fastness properties and as ready-made insoluble azo dyes on polyester, nylon and wool with good to very good fastness properties. The polyester dyed with ready-made azo dyes gave moderate fastness ratings without reduction clearing and the fastness properties were improved considerably to give good to very good fastness after subjecting to reduction clearing. Nylon gave good fastness even without subjecting to reduction clearing and wool, which could not be reduction

cleared in high alkaline conditions gave good fastness. The evenness of nylon and wool could be improved after soaping in a non-ionic detergent solution.

The colour fastness to light of all dyed samples were poor (rating 2) and further improvements should be carried out using after treatments. The wash fastness of cotton was moderate and could be improved using similar treatments. The ready-made azo dyes prepared showed different colour shades and produced different shades on different types of fabrics as well as on the same type of fabric.

In the case of cotton, the take up of polyphenols from the bath was difficult due to the poor substantivity of negative charged polyphenols to the similar charged cotton. Consequently, the use of an exhausting agent, a wetting agent, a suitable M.L.R. value, dye bath pH and higher dye bath temperature were tested to improve the up take. From the observations of these tests a 20.0g/l concentration of sodium chloride as the exhausting agent, 3.0g/l concentration of Newalol NF as the wetting agent, 1:50 of material to liquor ratio, ambient temperature as the dye bath temperature and a dye bath pH of 4.00 were chosen as the optimum conditions for exhaustion of polyphenols to cotton. Out of these conditions, acidic dye bath condition showed a considerable improvement of up take of polyphenols on to cotton since the cationic nature of polyphenols in acidic medium would be more substantive towards cotton fibre than its anionic form found in alkaline medium. But since Akaranta and Efanga had reported good in-situ azo dyeing on cotton using alkaline impregnation of red onion skin extract [30], both alkaline and acidic dye baths were used for in-situ azo dye application on cotton using tea polyphenols. In-situ azo dyes prepared on cotton using alkaline impregnation of tea polyphenols also gave reasonable dyeing with reasonable fastness ratings.

As a whole, polyester and nylon could be dyed successfully with ready-made azo disperse dyes prepared with tea polyphenols and wool could be dyed with ready made azo acid dyes prepared with tea polyphenols [46]. Cotton could be dyed with in-situ azo dyes prepared with tea polyphenols satisfactorily; specifically when the impregnation is done in acidic medium. Since the same ready made azo dyes dye polyester, nylon and wool in the same dye bath conditions, this could be further developed to one bath dyeing of polyester/nylon and polyester/wool blends.

The results obtained in this study show that tea leaves is a good natural resource for the substitution of naphthols and other phenolic compounds in the preparation of azo dyes, especially for dyeing polyester, nylon, wool and cotton. The abundance of this bioresource in the form of tea waste from factories and brewed tea from domestic sources, which still contain sufficient polyphenols to be used as the coupling component; indicates the possibility of the utilization of tea waste as an economical raw material for the production of azo dyes. This can be considered as environmentally friendly and economical method since it incorporates reuse of a solid waste for the manufacture of dye. When considering the large amounts of synthetic dyestuffs that is being used in Sri Lanka (and in the world) this type of azo dye derived from natural source has a significant effect on the environment as well as on the economy.

4.2 Future Work

- Colour fastness to washing of cotton dyed with in-situ azo dyes prepared from tea polyphenols could be improved. Treatments involving metal salts would result in hazardous effluents containing metal ions and natural mordents such as Myrobalan and Sumach or metals having less hazardous effects such as aluminium could be incorporated.
- Colour fastness to light of in-situ azo dyes as well as ready made azo dyes could be improved using similar treatments.
- Economical feasibility studies of the in-situ and ready-made azo dyes prepared from tea polyphenols could be carried out.
- Similar studies on ripened leaves of *Artocarpus integrifolia* and *Terminalia catappa* could be carried out.
- Colour measurements of the dyed samples could give a good understanding of the colours produced on fabrics.
- Good separation methodology for polyphenols and azo dyes could give more brilliance in colours.
- Identification and structural elucidation of the extracted polyphenols and the azo dyes prepared, using Infra Red Spectroscopy and Nuclear Magnetic Resonance Spectroscopy would give a good understanding of the behaviour of these compounds in dye baths and their mechanisms of dyeing.

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