4.0 SUMMARY AND CONCLUSIONS
Based on the studies outlined in the present thesis relating to modification of jute for improvements in textile related physical and mechanical property profiles and in processibility with respect to spinning of relevant fibres to yams, the following conclusions may be drawn:

A. Effect of Treatment with Plain Water, Steam, Alkali and Oxidative Agents

1. Plain water treatment, steaming, treatment with dilute NaOH solution and dilute oxidising agents (H$_2$O$_2$, K$_2$S$_2$O$_8$, NaIO$_4$) bring about notable changes in surface features and mechanical and textile related properties of raw jute fibre. In respect of all round improvement in the fibre properties and keeping textile applications in view, treated jute fibres corresponding to plain water treatment at boil for 30 min, steam treatment for 30 min (on wet jute fibre), dilute (0.5%) NaOH treatment at boil for 30 min or at 30°C for 60 min and those obtained from oxidative treatments of jute fibre using only H$_2$O$_2$ at 85°C, and a combination of H$_2$O$_2$ and K$_2$S$_2$O$_8$ at room temperature (30°C) have been found to be prospective for consideration for subsequent yarn making.

2. Mechanical processing of the raw jute fibre and the above prospective treated jute fibres (leading to sliver formation on carding and drawing unit and subsequently yarn making on a spinning frame (Apron draft jute spinning machine)) as subsequently studied in respect of (i) energy requirement and fibre droppings during carding, (ii) yarn breakage during spinning, (iii) moisture loss prior to spinning process and (iv) yarn properties as well as (v) irregularity infused in the yarn structure. Assessment of yarns made from the selected treated jute fibres and their comparison with the relevant data for the yarn prepared from the control jute fibre in the context of the overall property parameters as outlined above indicate that yarns made from jute fibres corresponding to (i) oxidative treatment using combination of 0.75% K$_2$S$_2$O$_8$ and 3% H$_2$O$_2$ at 30°C for 2 h and (ii) dilute alkali treatment (0.5% NaOH at 30°C, for 60 min) are most prospective and promising for durable and higher performance applications, in view of their zero end breakage during spinning and relatively high values for work of rupture, packing fraction, modulus and tenacity for the said yarns. Other prospective treatments in this respect are plain water treatment under boil and oxidative (H$_2$O$_2$) treatment at 85°C. Even though, steam treatment and dilute alkali treatment at boil involve much lower
energy requirement during carding, they are otherwise unsuitable in view of each of them being a high temperature process and each being characterised by a relatively low quality ratio and work of rupture and being not associated with much improvement in tenacity as well.

B. Effect of Treatment with Glycol and Acrylamide

1. Presoaking of jute fibre with 0.5% \( \text{K}_2\text{S}_2\text{O}_8 \) followed by an exposure to UV-light for 15min and subsequent treatment of oxy-jute fibre with 8% mixed PEG (50:50 mixture of PEG 200 and PEG 4000), 8% ethylene glycol (EG), 8% acrylamide and a mixture of 4% acrylamide and 4% PEG 1500 DP, offer notable benefits in respect of some consequential textile related property parameters, viz., fineness, weight gain, fibre tenacity, moisture regain etc. In respect of all round improvement in the fibre properties and keeping textile applications in view jute fibres treated as above appear prospective for assessment of spinnability for yarn making. Standard \( \text{H}_2\text{O}_2 \) bleaching of control and treated jute fibres imparts improvement in their whiteness index, brightness index and surface reflectance.

2. Assessment of yarns made from the selected treated jute fibres and their comparison with the yarn prepared from the control (raw) jute fibre in the context of the overall property parameters considered above indicate that yarns made from jute fibres corresponding to (i) oxidative treatment (using 0.5% \( \text{K}_2\text{S}_2\text{O}_8 \) at 30°C for 15 min at pH-5.5) followed by treatment with the mixture of 4% acrylamide and 4% PEG 1500) and (ii) oxidative treatment (using 0.5% \( \text{K}_2\text{S}_2\text{O}_8 \) at 30°C for 15 min at pH-5.5) followed by treatment with 8% ethylene glycol are most prospective and promising for durable and higher performance textile applications in view of their zero end breakage during spinning and relatively high values for work of rupture, packing fraction, modulus, tenacity, and resistance to microbial attack for the relevant yarns.

C. Effect of Treatment with Selected Enzymes and Silicone

1. Application of 4% enzyme mixture (containing cellulase, xylanase and pectinase) on jute fibre at 55°C for 2 h at pH 4.8 imparts optimal improvements in some important textile related properties of the fibre, making it much finer, softer, cleaner and
brighter, though with some loss in bundle tenacity. Pretreatment under combined oxidative action of 3% H₂O₂ and 0.75% K₂S₂O₈ for 2 h at 30°C followed by treatment with 1% mixed enzyme make jute fibre acquire much improved balance of important textile related properties including moisture regain, bundle tenacity, and flexural rigidity, surface reflectance, colour characteristic (K/S) and whiteness index and brightness index.

2. Treatment of jute fibre with control doses (0.5 to 1%) of aminosilicone makes the fibre much softer, smoother and brighter without much change in the bundle tenacity. In respect of all round improvement in the fibre properties and keeping textile applications in view, treatments prior to aminosilicone application by the action of a combination of 3% H₂O₂ and 0.75% K₂S₂O₈ for 2 h at 30°C (Expt No. 59, table 3.4), or by the action of only 3% H₂O₂ for 2 h at 85°C (Expt. No. 58 in table 3.4), have been found to be highly prospective.

3. Considering improvement in fibre processing in respect of yarn making as revealed by energy saving features, lowering in fibre dropping at cards and moisture loss prior to spinning, and also elimination or lowering of end breakage at the spinning stage and further considering improvements in overall yarn performance and yarn structure and appearance, it may be concluded that jute fibre can be more gainfully spun into yarns even without the use of jute batching oil if the fibre is selectively treated with 0.5% aminosilicone under specified condition. Jute, having subjected to treatment with 0.5% aminosilicone even without the use of conventional jute batching oil, produces yarns that are more soft and supple showing little loss in tenacity, good retention of packing fraction and substantial reduction in yarn imperfections consequent to measurable lowering in yarn mass irregularity.

4. Enzyme action on jute at 55°C for 2 h at pH 4.8 marginally improves its surface reflectance and brightness index though with a lowering trend in tenacity, quality ratio and specific work of rupture for the yarns along with relatively higher yarn breakage rate during spinning and these disadvantages together outweigh the gains in respect of energy saving and fibre-mass saving during carding and higher moisture retention upto the stage of spinning. Enzyme action using ~ 1% enzyme may be looked upon as a
process offering a net advantage in respect of processing (carding, drawing and spinning) and yarn performance.

In the final conclusion, considering the advantages achieved with respect to (i) the overall property improvements, (ii) improvements in energy efficiency and spinning process performance and (iii) also overall improvements in yarn properties including surface features, the raw and modified jute fibres may be rated in decreasing order of merit as follows:

1. \((\text{K}_2\text{S}_2\text{O}_8 - \text{treated})\) oxy-jute fibre further modified by treatment with ethylene glycol
   (Expt No. 30, Table 2.1) >

2. \((\text{K}_2\text{S}_2\text{O}_8 - \text{treated})\) oxy-jute fibre further modified by treatment with 1:1 mixture of acrylamide and PEG 1500
   (Expt No. 37, Table 2.3) >

3. Raw jute fibre treated with 0.5% aminosilicone
   (Expt No. 52, Table 3.3) >

4. \((\text{K}_2\text{S}_2\text{O}_8 - \text{treated})\) oxy-jute fibre further modified by treatment with acrylamide
   (Expt No. 33, Table 2.2) >

5. Raw jute fibre treated with a combination of 3% \(\text{H}_2\text{O}_2\) and 0.75% \(\text{K}_2\text{S}_2\text{O}_8\) at 30°C for 120 min
   (Expt No. 20, Table 1.2) >

6. Raw jute fibre treated with 3% \(\text{H}_2\text{O}_2\) at 85°C for 120 min
   (Expt No. 19, Table 1.2) >

7. Raw jute fibre treated with 0.5% \(\text{NaOH}\) soln. for 60 min at 30°C
   (Expt No. 13, Table 1.2) >

8. Raw jute fibre treated with plain water at boil
   (Expt No. 4, Table 1.1) >

9. Raw jute fibre treated with 1% enzyme
   (Expt No. 41, Table 3.1) >

10. Raw jute (untreated)
    (Expt No. 1, Table 1.1)