CHAPTER VII

SUMMARY AND CONCLUSION
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An investigation to study the effect of supplementing the ration of cross-bred lactating cows with copper and cobalt was undertaken. The results of the investigation carried out are presented and discussed in the thesis, along with the findings of similar investigations carried out by the other workers. The thesis comprises of six chapters.

1.00 The aim of the present study is presented in 'Preface'. The information on the importance of livestock wealth in the betterment of mankind and the country, as well as the role of trace minerals in animal nutrition form the introduction presented in the first chapter.

2.00 The literature available regarding the origin of feeding copper to the livestock, the inter-relationship of copper in soil, plant and animal body, absorption and excretion, concentration in body tissues, organs and fluids, hair and wool has been extensively reviewed in Chapter II. The role of copper in animal health, the deficiency diseases and their symptoms, blood formation and iron metabolism is dealt in detail. The inter-relationship of copper with other minerals and nutrients or dietary factors, copper requirements and supplementation levels have been discussed. The importance of copper in milk production as well as reproductive performance of milch animals have been indicated.
3.00 The detailed review of literature regarding the introduction and history of cobalt, the importance of cobalt in animal nutrition, species affected by cobalt deficiency, and its symptoms has been dealt in Chapter III. The terminology used in cobalt deficiency diseases in different parts of the world have been listed. The inter-relationship of the concentration of cobalt in soil, plant and animal body has been described. The role of cobalt in relation to feed consumption, digestibility of different nutrients, blood formation and synthesis of vitamin B₁₂ have been discussed briefly. The effective mode of administration of cobalt supplement to the ruminants has been stated. The effect of dietary cobalt on the production and composition of milk as well as the reproductive performance of milch animals has been reviewed.

4.00 The materials and methods employed in the present investigation are presented in Chapter IV. The plan of the experiment for the three levels of supplementation of both copper and cobalt to lactating cows have been included.

5.00 The results of the investigation have been presented and discussed in Chapters V and VI. Summary and conclusion of the work carried out and the results obtained are included at the end followed by Appendix and Bibliography.

6.00 Twenty Jersey x Tharparkar cross-bred cows were allotted to four groups having five animals in each to form one control and three experimental groups. The animals of three experimental groups were fed dietary supplements of 200, 300 and 400 mg of copper sulphate i.e., 52.0, 78.0 and 104.0 mg of
copper and 16, 24 and 32 mg of cobalt chloride i.e., 4.07, 6.10 and 8.13 mg of cobalt per day per animal during the first and second phases of the experiment, respectively. All the animals were on standard basal ration during the experimental period.

The composition of blood of the animals and the milk produced by them during the experimental period were studied at regular intervals. The milk yield and the reproductive performances of the animals were also recorded.

The analytical procedures followed for the analysis of blood, milk, feeds, faeces and urine are described.

A metabolism trial was conducted on two animals from each group at the end of six and half months of experimental period.

7.00 STUDIES OF COPPER SUPPLEMENTATION.

7.10 Effect of supplementation of copper to lactating cows on the haematological constituents of blood.

7.11 The average values of the packed cell volume of the blood the animals of control and experimental groups, I, II and III were 35.99±0.42, 40.06±0.65, 38.45±0.81 and 37.99±0.47 percent, respectively. The supplementation of copper resulted in a significant increase (P<0.01) of the PCV of the blood. However, the PCV of the blood of the animals of groups I and II as well as II and III were not significantly different from each other, while those of the cows of group I were superior over those of group III.
The average haemoglobin values of the blood of the animals of control and experimental groups I, II and III were 9.20±0.10, 10.66±0.28, 10.29±0.21 and 10.32±0.16 gm percent, respectively. Similar to PCV, the haemoglobin concentration of the blood of the animals fed copper sulphate supplement were significantly higher (P<0.01) than those of the animals of control group. The haemoglobin contents of the blood of the animals of the three supplemented groups did not differ from each other significantly. However, the group I recorded the highest value followed in order by those of group III and II.

The average red blood cell counts of the blood of the animals of control and experimental groups I, II and III were 6.13±0.18, 7.03±0.37, 6.32±0.40 and 6.54±0.43 millions per cumm respectively. The R.B.C. count was significantly higher (P<0.01) in the blood of the animals receiving the copper supplement than those of control group. The R.B.C. count of the blood of cows of groups I and II as well as II and III did not differ significantly from each other, while those of group I were superior over the values of group III.

The average values of white blood cell count of the blood of the animals of control and experimental groups, I, II and III were 8.48±0.89, 9.37±0.73, 9.80±0.77 and 9.13±0.51 thousands per cumm respectively. The W.B.C. count of the blood of the animals of supplemented groups were significantly higher (P<0.01) than those of control group. However, these did not differ significantly from each other.
7.15 The average values of the specific gravity of the whole blood of the animals of control and experimental groups I, II and III were 1.0484±0.0002, 1.0528±0.0003, 1.0511±0.0004 and 1.0512±0.0003, respectively. The specific gravity of the whole blood of the animals given copper supplement was significantly higher (P < 0.01) than those of control group. The specific gravity of the blood of the cows of groups II and III were similar, while those of group I was significantly different from those of the other groups.

7.20 **Effect of supplementation of copper to lactating cows on the biochemical constituents of blood:**

7.21 The average values of serum protein of the cows of control and experimental group I, II and III were 7.51±0.06, 7.59±0.07, 7.56±0.06 and 7.54±0.07 gm percent, respectively. The copper supplementation did not seem to affect the serum protein content significantly.

7.22 The average values of iron content of the blood of control and experimental groups I, II and III were 38.81±0.62, 47.70±0.66, 45.80±0.88 and 46.98±0.67 mg per 100 ml, respectively. A significant difference (P < 0.01) was observed between the iron contents of the blood of the animals of control and supplemented groups. The values of groups I and III as well as II and III were statistically similar, while the iron content of group I was significantly higher than that of group II.

7.23 The animals of control and experimental groups I, II and III recorded average values of 87.6±3.5, 117.9±3.2, 109.5±
3.1 and 107.7±2.6 mcg of copper per 100 ml blood, respectively. A highly significant difference (P < 0.01) was observed between the treatments. The values of groups I and II as well as II and III were similar. However, the values of group I was superior over those of group III.

7.30 Effect of supplementation of copper to lactating cows on the composition of milk:

7.31 The average values of milk fat recorded were 5.47±0.06, 5.28±0.10, 5.44±0.11 and 5.83±0.12 percent in the milk of the II animals of control and experimental groups I, II and III respectively. The supplementation of copper at the rate of 400 mg of copper sulphate per day per animal resulted in a significant increase (P < 0.01) in the butter fat of milk yielded. The butter fat content of milk of cows of groups I and II as well as II and control were statistically similar. However, the performance of the animals of group I was minimum in this respect.

7.32 The average values of protein percentages of milk of the animals of control and experimental groups were 3.43±0.03, 3.55±0.05, 3.56±0.04 and 3.62±0.05, respectively. The protein content of the milk of the cows of supplemented groups were significantly different (P < 0.01) and superior over those of cows of control group. The supplemented groups were statistically similar amongst themselves.

7.33 The average total solids contents of the milk of the II animals of control and experimental groups I, II and III were 14.85±0.09, 14.72±0.18, 14.98±0.15 and 15.37±0.163 gm percent, respectively. Similar to milk fat, the total solids
content was significantly higher ($P < 0.01$) in the milk of the animals of group III (400 mg), while that of the other groups were similar in this respect.

7.34 The milk of the animals of control and experimental groups I, II and III contained on an average $0.718 \pm 0.002$, $0.745 \pm 0.007$, $0.766 \pm 0.008$ and $0.763 \pm 0.007$ gm percent of ash. The total ash content of milk was influenced by the dietary supplementation of copper. A statistically significant difference ($P < 0.01$) was noticed between the ash contents in the milk of cows of the control and experimental groups. The values of groups II and III were found to be similar statistically, but superior over those of group I.

7.400 Effect of supplementation of copper to lactating cows on the intake and digestibility of nutrients and balances of minerals!

7.401 The metabolism trial indicated that the dietary supplementation of copper increased the dry matter ingestion as well as water consumption. The dry matter intakes in kg per 100 kg body weight of the animals of control and experimental groups I, II and III were 2.570, 3.017, 3.065 and 2.744, respectively. It was observed that the highest level of copper supplementation had a depressing effect on the intakes of dry matter. The water consumption in litres per 100 kg body weight of the animals of control and experimental groups I, II and III were 7.770, 8.750, 9.556 and 8.188, respectively. The dry matter ingestion as well as water consumption per 100 kg body weight of the animal were highest in the group II.
7.402 The digestibility of dry matter was highest in group I (68.15%). This was followed in order by group II (67.70%) and control group (67.29%). The lowest digestibility was observed in group III (63.87%). This indicated that higher level of supplementation 104 mg of copper per day depressed the digestibility of dry matter, while the lower levels of copper supplementation increased the same.

7.403 A similar trend was noticed in the digestibility of organic matter. The values for the digestibility of organic matter were 69.44, 70.52, 69.80 and 65.91 percent for the control and experimental groups I, II and III, respectively.

7.404 The highest digestibility of crude protein of the ration was observed in group I (71.50%), followed in order by group II (70.53%) and group III (66.57%). The lowest digestibility of crude protein was observed in control group (66.55%). At highest level of supplementation of copper, a depression in the digestibility of crude protein was seen.

7.405 The average digestibility coefficients of the other extractives of the ration observed for the control and experimental groups I, II and III were 89.32, 89.72, 89.86 and 90.70 percent, respectively. Groups I, II and control were found almost similar, while group III recorded a slightly higher value than that of control group.

7.406 The average values for the digestibility of crude fibre of the ration observed for the control and experimental groups I, II and III were 66.90, 68.32, 68.23 and 64.03 and
percent respectively. Supplementation of the ration with copper at lower levels was found to increase the digestibility of crude fibre, while at the higher level of supplementation, a depression in the same was noticed.

7.407 The average balances of nitrogen in the animals of control and experimental groups I, II and III were 37.98, 31.07, 30.70 and 18.65 gm per day per animal, respectively. The supplementation of copper was observed to favour a higher retention of nitrogen in the body of the animals, except at the highest level (104 mg copper) of supplementation.

7.408 The average balances of calcium were -3.63, -3.29, -2.27 and -1.92 gm per day per animal of control and experimental groups I, II and III, respectively. An increased retention of calcium in the body of the animals receiving the copper supplement, as compared to those of control group was seen.

7.409 The average values of retention of phosphorus per day per animal were 8.40, 6.99, 7.98 and 3.33 gm for the control and experimental groups I, II and III, respectively. The balances of phosphorus seem to be unaffected at lower levels of supplementation, while at highest level, a drop in retention was noticed.

7.410 The animals of control and experimental groups I, II and III retained an average 1.095, 1.091, 0.995 and 0.940 gm of iron in their body, respectively. The supplementation of copper was not beneficial in increasing the retention of iron in the body of the animals.
The average retention of copper in the body of the animals of control and experimental groups I, II and III were 37.265, 59.260, 55.670 and 33.111 mg per day per animal, respectively. The supplementation of copper favoured higher retention of copper in the body of the animals. However, increased level of supplementation did not result in a proportional increase in the retention of copper in the body of the animals.

Effect of supplementation of copper to lactating cows on their reproductive performance

Copper supplementation brought about the occurrence of earlier oestrus after parturition. The average number of days required for the animals of control and experimental groups I, II and III to come into oestrus were 66±3.6, 43±3.6, 48±6.6 and 48±6.0, respectively. The animals of supplemented groups showed post-partum oestrus within an average period of 46.3 days, as against 66.0 days in the case of animals of control group. The animals of group I (200 mg) recorded the minimum number of days in this respect.

Similar was the trend in the case of fruitful insemination numbers, the averages of which for the animals of control and experimental groups I, II and III were 6.0±2.8, 2.4±0.8, 3.4±1.6 and 2.2±0.4, respectively.

The average interval in days from calving to successful insemination of the cows of control and experimental groups I, II and III were 197.4±30.0, 85.0±23.4, 127.3±44.4 and 90.0±30.0,
respectively. The animals of group I (200 mg) recorded the minimum number of days in this respect.

Statistically significant differences were not seen in any of the three parameters of the reproductive performances of the animals, as a result of supplementing their ration with copper at three different levels.

7.60 Effect of supplementation of copper to lactating cows on the milk yield:

7.61 The average milk yields of the previous lactation were 2,313.2±220.1, 2,548.6±276.4, 2,461.4±224.3 and 2,224.6±30.3 kg, while that of the experimental lactation were 2,510.0±249.6, 3,235.0±354.6, 2,792.8±352.1 and 2,996.2±423.3 kg for the animals of control and experimental groups I, II and III, respectively. The increase in the milk yields of the animals of the supplemented groups during the experimental lactation over the previous lactation was higher than that of cows of control group. However, the differences observed were not statistically significant.

8.00 STUDIES OF COBALT SUPPLEMENTATION

8.10 Effect of supplementation of cobalt to lactating cows on the hematological constituents of blood:

8.11 The average values of the packed cell volume of the blood of the animals of control and experimental groups I, II and III were 39.42±0.54, 40.36±0.49, 37.92±0.61 and 37.71±0.49 percent, respectively. Dietary supplementation of cobalt at
the rate of 18 mg of cobalt chloride per day per animal was found to result in a significantly higher (P<0.01) PCV of the blood of cows than those of control group. Higher levels of cobalt seem to have an adverse effect on PCV of blood.

8.12 The blood of the animals of control and experimental groups I, II and III contained on an average 10.10±0.12, 10.43±0.10, 9.78±0.11 and 10.13±0.09 gm percent respectively. A similar trend as in the case of PCV was noticed in the case of haemoglobin content of blood also.

8.13 The average red blood cell counts of the blood of the animals of control and experimental groups I, II and III were 6.397±0.257, 6.607±0.283, 6.463±0.278 and 6.111±0.244 millions per cmm respectively. A significant difference (P<0.01) was noticed between the treatments. The R.B.C. values of the blood of the animals of control and experimental groups I and II were statistically similar and were superior over those of group III.

8.14 The average values of white blood cell counts of the blood of the animals of control and experimental groups I, II and III were 9.353±1.16, 8.928±1.24, 9.650±1.22 and 8.843±0.77 thousands per cmm respectively. The values of W.B.C. counts were found to be significantly different (P<0.01) due to treatments. A slight depressing effect was observed on this constituent of blood due to cobalt supplementation.

8.15 The average values of the specific gravity of the whole blood of the animals of control and experimental groups I, II and III were 1.0516±0.005, 1.0520±0.0004, 1.0500±0.0004 and
The specific gravity of the blood of the animals of group I was similar to that of animals of control group but significantly higher (P<0.01) than that of the animals of both the groups II and III.

8.20 Effect of supplementation of cobalt to lactating cows on the biochemical constituents of blood:

8.21 The blood of the animals of control and experimental groups I, II and III contained on an average 7.678±0.053, 7.619±0.056 and 7.556±0.062 gm percent of serum protein, respectively. A slight increase was observed in the blood of the cows of groups I and II which was not significant.

8.22 The average iron content of the blood of the animals of control and experimental groups I, II and III were 31.58±0.58, 34.17±0.52, 32.63±0.49 and 33.08±0.45 mg per 100 ml blood, respectively. The blood of the animals of all the supplemented groups recorded significantly higher (P<0.01) iron content than that of animals of control group. The blood of the animals of group I recorded the highest values.

8.23 The blood of the animals of control and experimental groups I, II and III contained on an average 115±1.23, 125±1.33, 120±1.53 and 120±1.1 mcg of copper per 100 ml blood, respectively. A significant difference (P<0.01) was observed between the treatments. The blood of the cows of group I recorded significantly higher copper content than those of control group. All the supplemented groups were statistically similar.
8.24 The average cobalt content of the blood of the animals of control and experimental groups I, II and III were 0.990±0.014, 1.600±0.116, 1.598±0.134 and 1.524±0.134 mcg per 100 ml of blood, respectively. Supplementation of cobalt at three different levels was found to be beneficial in raising the cobalt content of blood significantly (P<0.01). All the supplemented groups were not significantly different from each other. Highest blood cobalt content was recorded in the blood of the animals of group I.

8.30 Effect of supplementation of cobalt to lactating cows on the composition of milk:

8.31 The average values of milk fat recorded were 5.15±0.08, 5.14±0.06, 5.10±0.08 and 5.20±0.06 percent in the milk of the cows of control and experimental groups I, II and III, respectively. The dietary supplementation of cobalt did not seem to have any significant effect on the butter fat content of milk.

8.32 The milk of the animals of control and experimental groups I, II and III contained on average 3.43±0.02, 3.43±0.02, 3.34±0.02 and 3.41±0.03 gm percent of protein, respectively. A statistically significant difference (P<0.01) between the treatments was observed. The animals of group II recorded the lowest value for the protein content of their milk. All the other groups were statistically similar.

8.33 The average total solids content of the milk of the animals of control and experimental groups I, II and III were 14.624±0.08, 14.697±0.04, 14.624±0.08 and 14.689±0.11 gm percent respectively. Similar to milk fat, the cobalt supplementation
had no effect on the total solid content of milk produced.

3.34 The average values observed for the ash content of the milk of the animals of control and experimental groups I, II and III were 0.770±0.003, 0.787±0.004, 0.762±0.003 and 0.770±0.005 gm percent, respectively. The dietary supplementation of cobalt resulted in a significant increase ($P < 0.01$) in the ash content of milk. The ash content of the milk of cows of control and group III were statistically similar but significantly higher than that of cows of group II. The ash content of the milk of the cows of group I was significantly higher than that of animals of rest of the groups.

3.400 Effect of supplementation of cobalt to lactating cows on the intake and digestibility of nutrients and balance of minerals.

3.401 It was evident from the metabolism trial that the supplementation of cobalt resulted in an increase in the ingestion of dry matter and T.D.M. as well as water consumption. The average dry matter intake per 100 kg body weight of the animals of control and experimental groups were 2.757, 2.910, 2.736 and 2.824 respectively. The highest values for the ingestion of dry matter and consequently T.D.M. were recorded by the animals of group I. The average water consumption by the animals of control and experimental groups I, II and III were 3.01, 7.37, 7.67 and 7.40 litres per 100 kg body weight, respectively. The water consumption was highest by the animals of group II.
The digestibility of the dry matter of ration was highest in group I (68.51 %) and lowest in control group (65.09%). Groups II and III recorded 68.18 and 66.83 percent respectively, as the digestibilities of the dry matter of ration. At highest level of supplementation of cobalt, a depression in the digestibility of dry matter of ration was noticed. However, all the supplemented groups recorded higher digestibility of dry matter of ration.

A similar trend was noticed in the digestibility of organic matter. The values for the digestibility of organic matter were 67.38, 71.04, 70.59 and 69.61 percent for the control and experimental groups I, II and III respectively.

The highest digestibility of crude protein of ration was observed in group I (75.80 %) and the lowest in control group (72.57 %). Groups II and III recorded 74.72 and 75.47 percent as the digestibility of crude protein of ration respectively. It was observed that higher levels of cobalt supplementation tend to depress the digestibility coefficient of crude protein of ration.

The average digestibility coefficients for ether extractives of ration of control and experimental groups I, II and III were 80.13, 82.54, 83.38 and 84.22 percent respectively. Supplementation of cobalt resulted in increased digestibility of ether extractives of ration.

The average values of digestibilities of crude fibre of the ration observed for the control and experimental groups
I, II and III were 58.98, 62.35, 59.75 and 56.67 percent, respectively. The supplemented groups I and II recorded higher digestibility of crude fibre of the ration than that of control or of group III. Highest level of supplementation of cobalt resulted in a lowering of digestibility of crude fibre of the ration.

8.407 The average balances of nitrogen in the animals of control and experimental groups I, II and III were 36.99, 59.14, 55.20 and 59.16 gm per day per animal, respectively. Higher values of retention of nitrogen were recorded by the animals of all the supplemented groups.

8.408 The average balances of calcium were -3.03, -1.15, -1.98 and -0.20 gm per day per animal of control and experimental groups I, II and III, respectively. A slightly increased retention of calcium was observed in the animals of supplemented groups as compared to those of control group.

8.409 The average values of retention of phosphorus per day per animal were 0.08, 2.22, 1.67 and 0.73 gm in the animals of control and experimental groups I, II and III, respectively. Similar to calcium, the animals of all the supplemented groups retained higher phosphorus than those of control group.

8.410 The animals of control and experimental groups I, II and III retained on an average 1.032, 1.032, 1.409 and 1.353 gm of iron in their body, respectively. Supplementation of cobalt was found to be slightly beneficial in the assimilation and retention of iron in the body of the animals.
8.411 The average retention of copper in the body of the animals of control and experimental groups I, II and III were 15.569, 34.469, 25.437 and 20.190 mg per day per animal, respectively. Supplementation of cobalt to the lactating cows was found to favour the assimilation and retention of copper in the body. The highest retention was found in the animals of group I, and the lowest in these of control group.

8.412 The average retention of cobalt in the body of the animals of control and experimental groups I, II and III were -0.380, 2.173, 1.690 and 1.898 mg per day per animal, respectively. The animals of all the supplemented groups were in positive balance with respect to cobalt and those of group I recorded the highest retention of cobalt. Higher levels of supplementation did not result in a proportional increase in the retention of cobalt in the body of the animals.

8.50 Effect of supplementation of cobalt to lactating cows on their reproductive performance.

8.51 The post-partum oestrus was noticed in the animals receiving the cobalt supplement earlier than those of control group. The average number of days required by the animals of control and experimental groups I, II and III were 69.0±12.1, 49.6±14.0, 48.2±1.8, and 42.3±2.1 respectively, for the occurrence of post-partum oestrus. The animals of supplemented groups showed post-partum oestrus within an average period of 46.7 days, as against 69.0 days in the case of the animals of control groups. The animals of group III recorded the minimum number days in this respect.
A similar trend was observed in the case of fruitful insemination number, the averages of which for the animals of control and experimental groups I, II and III were 2.2±0.6, 2.6±0.5, 1.8±0.4 and 1.6±0.5 respectively.

The average interval in days from calving to successful insemination of the cows of control and experimental groups I, II and III were 95.2±30.3, 101.8±23.4, 78.2±12.2 and 64.0±19.4 respectively. The animals of group III recorded the minimum number days in this respect.

Statistically significant differences were not observed in any of the three parameters of the reproductive performances of the animals, as a result of supplementing their ration with cobalt at three different levels. However, the higher levels of supplementation of cobalt have shown the better performance.

Effect of supplementation of cobalt to lactating cows on the milk production:

The average milk yield of the previous lactation were 3,043.0±342.3, 2,714.0±125.6, 3,021.2±312.6 and 2,357.4±309.6 kg, while that of the experimental lactation were 2,985.6±303.7, 2,772.2±122.3, 3,084.0±155.5 and 3,163.2±394.2 kg for the animals of control and experimental groups I, II and III respectively.

The milk yield of the animals were found to be almost unaffected in the supplemented groups, except in group III, where a slight increase in the milk yield during the experimental lactation was observed, over the previous lactation. However, the statistical analysis of the data did not reveal any significant difference between the treatments.
9.00 It is evident from the results of the present investigation that the supplementation of the ration of cross-bred lactating cows with trace minerals such as copper and cobalt is beneficial in improving their physiological status, production and composition of milk, assimilating and retention of essential nutrients as well as the reproductive performances.

Supplementation of the ration of cross-bred lactating animals with copper at the rate of 200 mg of copper sulphate (52 mg copper) per day per animal has been found to be the optimum level of supplementation under good management and feeding, as supported by the observations on certain parameters studied in the present investigation.

Similarly, feeding of 16 mg of cobalt chloride (4.1 mg cobalt) per day per animal along with ration to the cross-bred lactating cows has been found to be beneficial in improving the physiological status of these animals, their productive and reproductive performances.

10.00 It is apparent that confinement raising of dairy animals together with the continuing improvement in their genetic inheritance by either selective or cross-breeding for rapid growth, early maturity and higher productivity is likely to change the requirements of nutrients including those of trace minerals. Therefore, it is recommended that supplementing the ration of cross-bred lactating cows with 52 mg of copper and 4.1 mg of cobalt per day per animal will be highly beneficial in improving their physiological status and performances. This would go a
long way in meeting the problems such as the probable higher requirements of nutrients, especially the trace minerals such as copper and cobalt, by these cross-bred animals and the reproductive problems encountered among the high yielding cross-bred animals.