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# Screening of oxalate content in soybean crop residue for livestock feeding

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**Abstract**
The incidences of renal toxicity and hypocalcaemia have been observed due to consumption of a substantial quantity of oxalic acid containing plants. The incidents like oxalate poisoning were reported from some of the parts of Maharashtra due to feeding of soybean crop residue (SCR). In view of this, it was decided to generate database on oxalate content of SCR. For this purpose, the SCR samples were collected from the major soybean cultivation area of Maharashtra State and were analysed for its oxalate content. The clinical findings in animals receiving SCR for more than two weeks as a major roughage component of ration indicated moderate to severe constipation, in some cases colic and in the later stage exhibited semisolid consistency of faeces. Similarly, decrease in milk production and poor body condition in adult animals while depression, stunted growth, emaciation, rough body coat, grinding of teeth, decreased rumen motility with pelleted faeces and hypothermia was noted in calves. The analysis revealed highest concentration of oxalate in soybean crop residue from Jalna (1.64 ± 0.03) and Buldhana (1.61 ± 0.03) districts while the lowest concentration was found in Latur (1.16 ± 0.13) and Nagpur (1.11 ± 0.08) districts of Maharashtra.

**Keywords:** Oxalic acid, soybean crop residue, cattle

## 1. Introduction

Oxalic acid is a simple organic acid present in a range of plant species commonly that gets ingested by ruminants in some less-favoured areas through grazing or coarse crop residues [3]. A wide variety of plants including feed stuff and forages, *Cenchrus ciliaris* (buffel grass), *Anagallis arvensis* (Niliphuli), Rice straw, *Pennisetum clandestinum* (kikuyu grass), *Pennisetum purpureum* (napier grass), *Digitaria decumbens* (pangola grass), *Amaranthus spp.* (pigweed), *Rheum rhaponticum* (rhubarb), *Salsola kali* (Russian thistle), *Setaria sphacelata* (setaria) and *Beta vulgaris* (sugar beets) can accumulate large amounts of oxalate in some circumstances leading to poisoning in farm animals [15]. Earlier, high oxalate content has been reported in *Anagallis arvensis* weed which on consumption lead to oxalate toxicity in grazing animals in Marathwada region of Maharashtra [9]. Renal toxicity and hypocalcaemia may also occur due to the consumption of a substantial quantity of oxalic acid containing plants [19]. Such oxalate-rich plants may become important forage resources for ruminants when other feedstuffs are in short supply, especially in saline lands or in arid and semi-arid regions.

Soybean Processors Association (SOPA) of India (2014) along with other associate agencies conducted extensive crop survey in three major Soybean Producing States i.e. Madhya Pradesh, Maharashtra and Rajasthan from India. As per SOPA's satellite survey [18], the area under soybean cultivation in Maharashtra was 35.852 lac hectares during Kharif-2015 of which Vidarbha region had 19.224 lac hectares and Marathwada region had 13.058 lac hectares area under cultivation, contributing 53.62% and 36.42% share of soybean cultivation in Maharashtra, respectively. Soybean crop residue is a major source of dry roughage to the livestock and being utilized as a fodder to greater extent in soybean cultivation area of Maharashtra. Due to feeding of soybean crop residue (*Kutar*), incidents like oxalate poisoning were noticed and frequent queries were received from livestock owners regarding adverse health effects in cattle receiving SCR. from some parts of Maharashtra which impelled to investigate oxalic acid content in Soybean Crop Residue (SCR). Hence, having larger area under soybean cultivation and feeding soybean crop residue to animals, it was planned to screen the SCR from Vidarbha and Marathwada regions of Maharashtra for its oxalate content.

## 2. Materials and Methods

The samples of Soybean Crop Residue containing threshed portion of soybean except seeds were randomly collected from 12 soybean crop producing districts belonging to different agro-climatic zones of Vidarbha and Marathwada regions of Maharashtra. The clinical examination of the animals was also carried out in details, which included recording of body temperature, heart rate, respiration rate, appetite, alertness, act of defaecation, ruminal movements, condition of muzzle, muscle tremors etc. The samples collected were from farmers offering SCR fodder as a sole roughage source to their cattle. The oxalate levels in SCR were determined by the titrimetric method as described by [1]. The collected data was analyzed statistically by using standard statistical methods [17].

## 3. Results and Discussion

The history and data of clinical examination recorded revealed that, the body temperature, heart rate and respiration rate were within normal range, however, the ruminal movements were decreased. These animals became moderate to severe constipated after one-two weeks continuous consumption of SCR. In the later stage some of the animals passed semisolid faeces. In milking cattle decrease in milk production, loss of body weight, emaciation and poor body condition was observed. The experiment conducted by [10] on effect of feeding soybean straw on intake and milk Production of 12 lactating cross bred cows and concluded that incorporation of soybean straw had no negative effects either on dry matter intake or on the milk production of cross bred cows which is in disagreement with the current findings of decrease in milk yield in cows receiving SCR. This could be due to poor calcium availability for milk production in cows fed with SCR; it could be attributed to compositional variation of soybean straw content. In general, oxalate content is high in the leaves than in the seeds, and lowest in the stems [16]. Soybean crop residue includes stem, leaves and soybean pods however, the portion of leaves is very meagre as it gets shade down during harvesting and threshing of soybean crop leaving more stem and pod parts which are low in nutrition. Thus, the variation in oxalate content and its clinical manifestations also depends on the composition of SCR. If the SCR contains more leaves, pods and seed then it may concern the clinical significance on health of animals receiving such SCR, leading to oxalate toxicity. The decreased milk production in the present investigation can be attributed to the chelating effect of oxalate with calcium leading to less availability of calcium required for milk production as oxalate binds and forms insoluble compounds with some essential minerals including calcium, iron, zinc and magnesium. Oxalate also inhibits mineral absorption [13]. The same can be correlated to low milk production, rough body coat and poor body condition in cattle observed in the present study.

Depression, stunted growth, emaciation, rough body coat, grinding of teeth, decreased rumen motility with pelleted faeces and hypothermia was common in growing calves receiving sole SCR feeding which are in agreement with the findings of [7] who evaluated oxalate toxicity in ewes with feeding on Beet tops (*Beta vulgaris*) and reported depression, anorexia, tachypnea, tachycardia, hypothermia, tremors, and ruminal hypomotility as the most commonly observed typical signs with teeth grinding, voiding of soft pellets, absence of recumbency, non-tympanic rumen, dry mouth, and thin body condition were the most prevalent atypical findings.

The incidence of retarded growth and poor body condition in bull fed on Napier silage was attributed to high oxalate content of Napier [4]. Further, it has been observed that the animals receiving SCR since long period (> 2 to 3 weeks) were getting adapted to the feeding and has not manifested any clinical illness or oxalate toxicity symptoms except semi-solid faeces indicating indigestion. The rumen microflora can increase their oxalate degradation capacity by proliferating their population with gradually increasing oxalate diets [2]. Gradual exposure to increasing levels of oxalic acid leads to an adaptation of the rumen microbiota, the breakdown of this compound preventing its detrimental consequences [5]. It has also been reported that hungry and unadapted ruminants are the most susceptible to oxalate intoxication. If ruminants are slowly exposed to a diet high in oxalate (over an approximately 4-day period), the population of oxalate-degrading bacteria in the rumen will increase to a level sufficient to prevent oxalate poisoning [12]. A long time *ad libitum* feeding of SCR may lead to increased oxalate degradation capacity and adaptation of rumen microflora, however, it causes mineral imbalances to some extent, leading to retarded growth and poor body condition in such animals.

The mean oxalate content of 80 SCR samples collected from 12 selected districts of Maharashtra under study are presented in the Table 1.

**Table 1:** District-wise mean oxalic acid content (g/100g) in Soybean crop Residue (SCR)

| S. No. | Name of District | Mean values of Oxalate in SCR (g/100 g) |
|---|---|---|
| Vidarbha Region (n =45) | | |
| 1 | Nagpur | $1.11 \pm 0.08^{c}$ |
| 2 | Wardha | $1.49 \pm 0.08^{ab}$ |
| 3 | Yeotmal | $1.51 \pm 0.05^{ab}$ |
| 4 | Akola | $1.33 \pm 0.07^{bc}$ |
| 5 | Amravati | $1.35 \pm 0.09^{bc}$ |
| 6 | Buldhana | $1.61 \pm 0.03^{a}$ |
| | C. D. (1% & 5%) | 0.33 and 0.25 |
| Region Mean | | $1.39 \pm 0.04$ |
| Marathwada Region (n=35) | | |
| 7 | Parbhani | $1.58 \pm 0.04^{a}$ |
| 8 | Nanded | $1.45 \pm 0.12^{ab}$ |
| 9 | Latur | $1.16 \pm 0.13^{c}$ |
| 10 | Beed | $1.25 \pm 0.15^{bc}$ |
| 11 | Jalna | $1.64 \pm 0.03^{a}$ |
| 12 | Hingoli | $1.41 \pm 0.06^{ab}$ |
| | C. D. (1% & 5%) | 0.38 and 0.29 |
| Region Mean | | $1.45 \pm 0.05$ |

Statistical analysis of the data revealed that the districts of Vidarbha region have significant differences ($P<0.01$ and $P<0.05$) in oxalate content of SCR. Highest concentration of oxalate (1.61 ± 0.03) in soybean crop residue was found in Buldhana district followed by Yavatmal (1.51 ± 0.05) and Wardha (1.49 ± 0.08) districts showing the significant difference from Akola, Nagpur and Amravati districts of Vidarbha. The lowest SCR oxalate concentration was recorded from Nagpur (1.11 ± 0.08) followed by Akola and Amravati depicting non-significant differences (Fig.1).

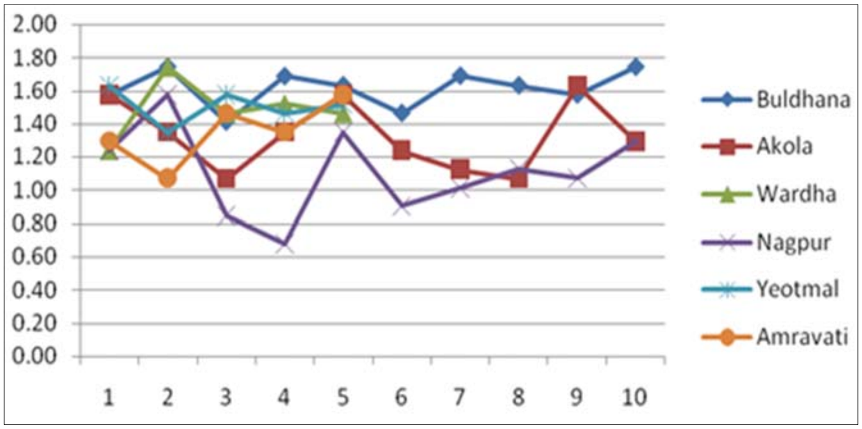


**Fig 1:** Mean Oxalate concentration of SCR from Vidarbha region.

In Marathwada region also all the districts under study registered significant difference ($P<0.01$ and $P<0.05$) in oxalate content of SCR. The soybean crop residue from Jalna district showed highest oxalate (1.64 ± 0.03) concentration than the other districts of Marathwada region however, the lowest oxalic acid content (1.16 ± 0.13) in SCR was observed in Latur district. The oxalate content in SCR was non-significantly differed in Beed and Latur districts (Fig.2).

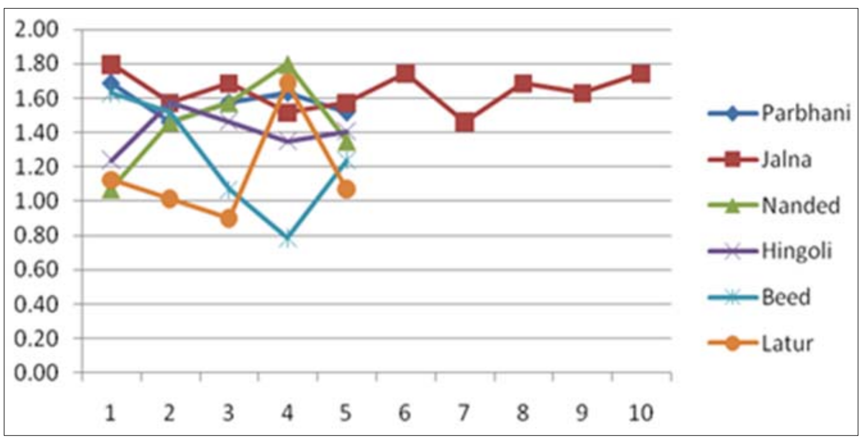


**Fig 2:** Mean Oxalate concentration of SCR from Marathwada region.

The region-wise comparison showed non-significant difference in oxalate content of soybean crop residue of Vidarbha (1.39 ± 0.04) and Marathwada region (1.45 ± 0.05). The mean total oxalate concentration in the seeds of soybean in Kenya was analyzed as 1.665 g oxalic acid per 100 g of dry weight [6] which corroborates with the current findings of oxalate concentration in SCR in Jalna and Buldhana districts. The oxalate content of seeds from 11 varieties of soybean has also reported with high levels of total oxalate ranging from 0.67 to 3.5 g/100 g of dry weight [8]. Reviewed literature showed that cattle and sheep are less affected because of degradation of oxalate in the rumen. However, cattle mortalities from oxalate poisoning due to acute hypocalcemia have occurred on setaria pastures and sheep have been poisoned while grazing buffel grass have reported by [11], they also reported that the levels of 2 per cent or more soluble oxalate can lead to acute toxicosis in ruminants. The oxalate content of SCR analyzed in the present study was within the safe limit (< 2%) of ruminants [14].

## 4. Conclusion

The present investigation concluded that the consumption of soybean crop residue (SCR) for more than two weeks leads to moderate to severe constipation, colic and semisolid consistency of faeces, decrease in milk production and poor body condition in adult cattle while depression, stunted growth, emaciation, rough body coat, grinding of teeth, decreased rumen motility with pelleted faeces and hypothermia was noted in calves. The highest concentration of oxalate in SCR from Jalna (1.64 ± 0.03) and Buldhana (1.61 ± 0.03) districts while the lowest concentration was found in Latur (1.16 ± 0.13) and Nagpur (1.11 ± 0.08) districts of Maharashtra. The variation in oxalate content of soybean crop residue (SCR) and clinical manifestations due to its feeding to cattle depends on the composition of SCR. If the SCR contains more leaves, pods and seed then it may concern the clinical significance on health of animals receiving such SCR, leading to oxalate toxicity. The oxalate content of SCR from the different parts of Maharashtra under study was within the safe limit (≤2%) for ruminants under normal management and climatic conditions.

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