Sugar Versus the Intuitive Choice of Foods by Livestock

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IT HAS been known for centuries that livestock, and animals in general, have food preferences. It has also long been known that cattle, for example, prefer forage from well-fertilized pastures over that from non-fertilized pastures, other things being equal. Observations along this line have led many persons to believe that grazing animals are wise in their ways and know intuitively that vegetation on the fertilized soil is richer and better balanced in food nutrients than that on the unfertilized soil; consequently, the fertilized forage is better for them. Such an ability to choose foods is a faculty, or gift, which even human beings cannot be said to possess.

A particularly interesting negative example of "food choice" is that of animals in pastures refusing to eat grass whose growth has been influenced by their droppings (Fig. 1). Some pastures of small size become almost worthless because they are highly spotted with untouched bunches of lush, dark-green, healthy-looking, manure-affected grass. The normal, or unaffected, grass may be mediocre, or even poor, in appearance; yet it will be eaten to the complete exclusion of the lush grass. Various reasons have been offered in order to explain this phenomenon and the present paper is an attempt to throw further light on the matter.

Present Work

The question of what makes feed or forage palatable or unpalatable is still a moot one. Some of the factors which are believed to influence palatability are kind of feed, and physical and chemical nature of the feed, including all the significance which these things connote. A further important factor, surely, is the degree of familiarity, or accustomedness, which animals have with any particular feed material. A general discussion of the subject does not come within the purview of the present work, however, and only that part related to manure-affected plant growth will be dealt with.

In an effort to learn something about the matter, many chemical analyses of plants have here been made over a period of years to find a substance, or substances, in such plants which might make them unpalatable, or repugnant, to animals; further, to see whether a nutrient, or mineral imbalance in the plants could be such a factor. Several things, including tannins, coumarins, nitrates, etc., are believed to decrease forage palatability.

Included in the study were certain weeds and grasses which are seldom, or never, touched by grazing animals. Among these were certain perennial legumes, including the false indigos (*Baptisias*), the wild alfalfas (*Psoraleas*), wild lespedezas, broomsedge grass (*Andropogon virginicus*) and "doghair", or "tickle" grasses (*Aristida* sp.). It was found that these plants, particularly the legumes, contain considerable tannin material. This is formed in plants in greater amounts during certain years than others. There was a seeming direct correlation between the amount of tannin in a plant and whether an animal would eat it, or not even nibble at it. However, it was found that the more tannin present, the less sugar there was in a plant. Also, as will

be enlarged upon later, if tannin is distasteful, it can be "neutralized" or at least camouflaged with a coating of sugar. Coumarin and nitrates evidently had no effect on palatability.

very surprising, at all, when one stops to remember that many animals have been converted to pets—even slaves—merely by feeding them sweet things, including pastries.

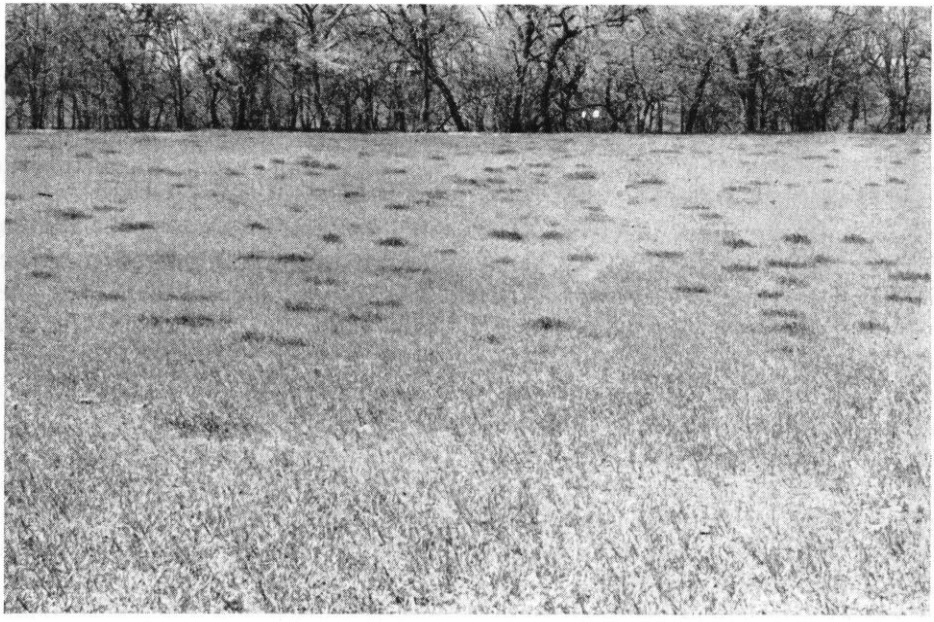

FIG. 1. Manure-affected spots in a grazed wheat field.

In analyzing various forage plants which *were*, and which *were not*, influenced by animal droppings it was found that, in every instance, these plants had constant and distinct differences in their nutrient content pattern. Lush, manure-affected plants were always higher in protein, calcium, potassium, iron, fat, nitrates, and vitamins. The normal, or manure-unaffected plants were always higher in silica, alumina, phosphorus, tannin, chloride, and sugar.

A study was next made wherein manure-affected and manure-unaffected plants were "balanced" as well as possible in their respective nutrient makeups and then fed to cattle. It was finally indicated that when sugar, alone, was added to the lush plants the animals not only ate them readily, but greedily. This is probably not

COWS LIKE SUGAR

In light of this information a spraying experiment was made with various concentrations of different sugar solutions, using a knapsack sprayer. Lush, manure-affected growths were sprayed in both native-grass fields and in fields of pastured small grains. The following sweetening materials were used: table sugar, black-strap molasses, sorghum molasses, and corn syrup. These were used in 30 percent solutions, which concentration was found to spray on well. Other concentrations were also used.

It did not take grazing animals very long to discover the sprayed plants and then to consume them completely. In several instances, during spraying operations, the cattle quickly became aware of what was going on and followed the spray-

ing can around expectantly. There was an evident order of preference for the sweetening materials, as follows: blackstrap, sorghum, sugar, and corn syrup. The sugar (sucrose) was always preferred to the corn syrup (glucose, mainly) doubtless because of its greater sweetness. Also, the cattle preferred the more concentrated solutions tested, up to the maximum that the spray nozzle used would put out.

Next, various plants which grazing animals disdain were treated with the same sweeteners. Included were perennial legumes and broomsedge and three-awn grasses. In all instances when these plants were sugarcoated they were eaten readily.

Now it is known that some unpalatable forages may sometimes be made more appetizing by salting them. In order to see whether the various sugars herein used had been exerting a "salt effect", plots were laid out in a field of mostly broomsedge. The following salts were made into dilute solutions (approximately 3 percent) and sprayed on marked areas: the chlorides, nitrates, phosphates, and sulphates of ammonia, calcium, magnesium, and potassium. Also used were one tenth percent solutions of the sulphates of cobalt, copper, and zinc, and 3 percent solutions of phosphoric, lactic, acetic, and ascorbic (vitamin C) acids, and cider vinegar. Close observation of cattle turned in on the plots showed that these substances elicited slight enthusiasm from them and they grazed quite disinterestedly. The vinegar was an exception to this. When sweetened vinegar was used the cattle became quite pleased and devoured all such treated broomsedge completely.

Cows Like Saccharine

It now appeared that the palatability-inducing agent was sugar, particularly if aromatic substances were added to it. But sugar is a real food which is high in energy. The rather impetuous acceptance of it by animals—especially cattle and horses—seemed to indicate a nutritional intuition on their part, or an autonomic intelligence. On the other hand, there remained the possibility that the mechanism of the palatability-enhancing property of sugar was simply and entirely its sweetness. Further sprayings were then made on broomsedge, and other unpalatable forages, using very dilute solutions of the synthetic sweeteners, saccharine and sodium cyclohexyl sulfamate. These things exert a sweetness many times that of sugar and have no caloric, or other food value whatever. By observation it soon became evident that the cattle liked anything sweet whether it had food value or not. In fact, saccharine, aromatized with vinegar or anise oil, was preferred to plain sugar and was equal to blackstrap molasses in causing low-quality forage to be relished by the animals.

Another interesting observation in connection with animal wisdom and their preference for things to eat is that of cattle and horses choosing "caramelized" or "naturally ensiled" alfalfa hay over fresh, green, No. 1 alfalfa hay. In numerous instances, under local conditions, when alfalfa is cut and immediately baled and stacked in the field, that which is baled earliest in a too-moist condition, often goes through a fermentation, or "caramelization", process. In this process, which is a kind of ensilation, sugars, acids, and aromatics are formed. At the same time, however, the market grade and feeding value of the hay is lowered rather drastically, but palatability is evidently improved (Bohstedt, 1944). In several instances when samples of both fresh No. 1, and dark brown, fermented hay were placed before cattle and horses, the latter hay was entirely eaten before the bright hay was more than touched. However, when the bright hay was treated with

blackstrap molasses, no significant difference in choice between the hays was evident.

TABLE 1

Analysis of manure-unaffected (normal) and manure-affected (lush) wheat plants

ITEM	UNIT	NORMAL	LUSH
N	%	1.27	2.36
Ash	%	8.59	7.51
SiO_2	%	3.47	1.74
P_2O_5	%	.49	.13
Fe_2O_3	%	.01	.07
Mn_3O_4	%	.011	.014
CaO	%	.56	.78
MgO	%	.33	.35
K_2O	%	2.01	3.93
Na_2O	%	.27	.23
SO_4	%	.21	.22
Chlorides	%	1.93	.61
Tannins	%	1.11	.37
Fat*	%	2.04	3.59
Fiber*	%	22.15	21.47
Sucrose*	%	3.74	1.24
Reducing Sugars*	%	2.97	2.01
Carotene*	PPM	96	361
Niacin*	PPM	19	46
Riboflavin*	PPM	10.38	17.28
Thiamin*	PPM	2.86	3.06
Nitrates	PPM	7	17
Acidity	pH	5.6	5.7

* The elements starred were determined by members of the Department of Agricultural Chemistry, to whom many thanks are hereby tendered.

In Table 1 are shown some of the chemical differences and similarities between samples of wheat plants taken from an unfertilized field which had been rather heavily pastured. One sample consisted of plants which were manure-influenced (lush). A second sample was made up of uninfluenced (normal) plants. The samples were taken when the plants had headed out and the grain in both was in the milk stage, thus they were in the same state of maturity. This condition is necessary to get a fair comparison of the mineral makeup of the two samples of plants. However, side analyses have shown that this is unfair to the normal wheat plants from the standpoint of sucrose content; if the samples had been taken a week or ten days earlier, these plants would have been still higher in this sugar.

The grazed plants were light yellowish green in color while the ungrazed ones were still dark green, shiny, and quite lush. Fifteen "bunches" of manure-affected plants were collected from an area about 60 feet square, and an approximate amount of manure-unaffected plants was taken from the same area. The samples were ground fresh, mixed thoroughly, and aliquots taken for vitamin analysis. The remaining amounts were air dried rapidly and samples taken for mineral and sugar analysis. Although the data presented were obtained from wheat plants, pasture grasses have an almost identical constitutional pattern under the above circumstances.

From the standpoint of the present study, the most interesting features of the analysis are taken to be the vitamin, sugar and phosphorus contents of the two samples. The lush plants have the advantage in vitamins and the normal plants have it in the two latter substances. It is believed that, in view of the spraying demonstrations, the lush plants were ungrazed not because of their high vitamin, or low phosphorus content, but because of their low sugar content. That is, sugar seems to be the element that made for palatability and thus for preference by the grazing animals. The phosphorus content seems thus to be only incidental as far as palatability and grazing choice are concerned. But, phosphorus is an absolute requirement for sugar formation in plants!

Tests made on fresh cow manure showed it to be high in available nitrogen and potash and low in available phos-

phorus. Animals void considerable phosphorus in their urine and further tests showed that this is practically entirely available to plants. When aliquots of cow urine, one gallon each, were added to one-foot-square areas in a field of young wheat plants, they also caused increased growths. These differed from those caused by fresh cow dung in several ways. First, they were readily eaten by the grazing animals. In addition the plants did not assume the dark-green coloration which the dung-affected plants did. Analysis showed that the composition of the wheat plants on the urine spots was almost identical to that of the surrounding, unaffected plants—even in sugar content.

Cattle Like Anything Sweet

Fresh cattle manure may possibly be looked upon as an unbalanced source of plant nutrients. It is high in available nitrogen which causes luxuriant growth of plant substance at the price of low phosphorus intake. This evidently results in a phospho-nitrogen imbalance which prevents normal sugar formation in affected plants and thus decreases their palatability. Numerous analyses of wheat and grass plants from fields fertilized with good, complete fertilizers, or *well-rotted* manure, show normal contents of minerals and sugars. In some instances noted, phosphate, alone, produced greater sugar formation in plants than did complete fertilizer. When nitrogen is used alone, and in a fairly large amount, affected plants assume a composition quite similar to that of fresh dung-affected plants. That is, they are high in nitrogen and low in phosphorus and sugar, etc. In this condition such plants are not eaten readily by animals. Here again, however, if such nitrogen-fertilized plants are sweetened with sugar they will, seemingly, be considered palatable by the animals.

Does Sugar Content Mean Degree of Palatability?

In a palatability grazing test of the plants of several fall-sown grains at the Oklahoma Agricultural Experiment Station (Staten, 1949) it was concluded that a number of factors may influence the immediate and particular choice of vegetation by cattle; also that it would probably be impossible to arrange such a grazing experiment so as to get all of the involved factors equal or uniform for the entire time. Although there was evidence that the animals relished barley more than the other plants on the unfertilized area, they preferred the plants, in general, on the fertilized plots in every instance.

The above experiment was not connected with the present work, but since no chemical, or other, study was to be made of the various grain plants therein involved, it was felt that such a side study might prove of interest and value. Samples of both the fertilized and unfertilized plants were taken for analysis. Owing to the rather sparse covers only two samples were made. That is, a handful of plants from each of the fertilized plots was taken and mixed to make a composite sample. A sample from the unfertilized plots was obtained in the same manner. Analysis later showed that the fertilized forage averaged 21 percent higher in phosphorus and 37 percent higher in total sugars than the unfertilized forage. These particular increases are not nearly so large as have been found for some other fertilized versus unfertilized forages, but evidently were sufficient for the cattle to recognize and appreciate. In this experiment the fertilizer used was 20 percent superphosphate, at the rate of 150 lbs. per acre. Side studies herein indicate that, if triple the above amount of phosphorus had been used, at least double the amounts of phosphorus and sugar might have been

found in the forage. This would undoubtedly have further enhanced the palatability of the forage and would have produced more dry matter at the same time.

Discussion and Conclusion

A study of the data in Table 1 indicates that when grazing animals prefer the normal wheat plants to the lush plants, they pass by something which has the advantage in several respects, including more protein, lime, fat, iron and vitamins and less tannic material. On the other hand they get more phosphorus, sugar, chlorides, and silica. It is believed that some day, silica will be found to be an important nutrient material. The significance of the chlorides is not fully understood, but in all analyses made, they occurred in direct relationship to sugar content.

In light of the observed reactions of the grazing animals to sugar it seems certain that the animals did not eschew the lush, manure-influenced forage plants because they (the animals) were fastidious, finicky, or pernickety, or because the plants uninfluenced by manure might have been better for them nutritionally, but because the manure-affected plants were lower in sugar content. Also, they probably did not choose the fermented alfalfa hay over the bright-green alfalfa because either one or the other might have had more food value. Further, they probably did not suddenly take a notion to eat the sugar-sprayed broomsedge, or other inferior forage materials, because of any knowledge of the food value of the sugar. If so, those animals which "mistook" saccharine for sugar were being contrary.

In the present light, and in view of the huge amount of *sweetened, ground corncobs*, and other molasses-treated, inferior feed materials which are now being daily consumed and evidently relished by domestic herbivores, the idea that the latter know intuitively "good" foods from "bad" must pass into penumbra. Instead, it seems that the animals, like humans, have a "sweet tooth" and will eat sweet things "misguidedly" in order to satisfy this craving. In other words animals, like people, often eat what they like best before they eat what is best for them.

As a possible result of this seeming fact, owners of grazing animals may take advantage of the situation and get rid of non-marketable, unpalatable, poor-quality, and otherwise disdained forage materials by sweetening them with blackstrap molasses, etc., and feeding them to the animals. Weedy fence rows and corners, ditch banks, other weed-infested areas, and unwanted hay and strawstacks, etc., might be eliminated by spraying them well with a good sweetener and turning grazing animals in on them. Of course, poisonous plants should not be thus treated and offered to the animals.

It is here believed, however, that the best way to take advantage of the sugar-liking propensity of forage eaters is to fertilize the growing plants well. Phosphorus is especially necessary for sugar formation in plants. Further, managers who cut forages for hay can enhance the palatability thereof by cutting them fairly late in the day. It is known that plants form sugars during daylight hours and use them up during hours of darkness (Kellner, 1915; Miller, 1938; Tottingham, 1937). Therefore there is more sugar in a plant in the afternoon than there is earlier in the day.

Another special case involving lush, high-nitrogen grass is described by Albrecht (1951). This is the "Fairy Ring" phenomenon in which grass growth is stimulated by a soil fungus and grows in a characteristic ring, or circle, formation. The ring grass is more lush, darker green, and higher in nitrogen and the various amino acids than the normal grass. How-

ever, it was not stated whether such grass is readily eaten by animals, or not.

SUMMARY

It has long been known that grazing animals do not eat vegetation which has been influenced by their droppings. Chemical study shows that lush, manure-affected plants are significantly lower in sugar content than manure-unaffected plants and this apparently makes them unpalatable to animals. When lush, ignored plants were sprayed with sugar solutions they were eaten readily by grazing animals. That it was not the sugar, *per se*, which produced the increase, or improvement, in palatability of the lush plants was seen when such plants, sweetened by saccharine and sodium cyclohexyl sulfamate, were eaten as readily as those sweetened with blackstrap molasses, particularly when aromatized with vinegar or anise oil.

That grazing animals are not endowed with intuitive ability of choosing foods which are nutritionally best for them was seemingly demonstrated by the fact that several inferior and unpalatable forage materials, including mature broomsedge, were eaten readily when they were well sweetened. On the other hand many animals have been made into pets simply by feeding them sugar, or even pastries. Advantage might be taken of this sweet-tooth proclivity of grazing animals, occasionally. Weedy fence rows, ditch banks, etc., might be sprayed with blackstrap molasses and animals turned in on them. Poisonous plants should not, of course, be thus treated. It is advised that the best way to cater to the sweet appetites of grazing animals is to fertilize forage crops with sufficient available phosphate. This will produce more forage which has a higher sugar content and is more palatable.

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