

THE POSSIBILITY OF INCREASING MILK AND BUTTERFAT PRODUCTION BY THE ADMINISTRATION OF DRUGS¹

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The secretion of milk, being an extremely complicated process, is subject to many variations and though some of the factors influencing it are understood, many others are unappreciated or even unknown. For a long time it has been believed that many drugs have the power of influencing milk secretion and, owing to the popularity of official and semi-official testing of dairy cows, this is of special interest at the present time.

Within recent years some men undoubtedly have tried to influence favorably the production of their test cows by means of drugs and consequently when a cow makes an exceptional record there are many ready to affirm that drugs must have been used to bring about the phenomenal results. Consequently some breed associations prohibit the use of such substances with cows on test and it is not uncommon for association officials to make public denial of the use of drugs in connection with the making of certain records.

The present work was undertaken, with the coöperation of Dr. H. D. Bergman, of the Department of Physiology and Pharmacology, of the Veterinary Division of the Iowa State College, to test the validity of some of these statements regarding the use of drugs with milk-producing cows.

The knowledge of the effect of drugs on the active mammary gland is very incomplete and, though admitting the fact that drugs might under certain circumstances alter milk secretion, the veterinary profession does not recognize any direct galactagogues.

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No attention will be given here to experimentation with the human subject, the goat, or mammalia other than the cow, for the simple reason that though much valuable work has been done with these subjects the results need not necessarily be directly applicable to the cow as there may be certain generic differences in physiological activity, and it is known that in some cases, e.g., with the human subject, variations in milk production can be brought about much more readily than in the case of the cow.

There are various ways in which the activity of the udder might be influenced by drug action and amongst these are the following:

1. Direct action of the drug on the protoplasm of the secretory cells.
2. Influencing the secretory nerve terminations.
3. Vasomotor influences with a resulting change in the amount of blood supplied to the active mammary tissue.
4. Variation in the heart's action with a possible influence on circulatory conditions.
5. Action on the digestive system, thus influencing the amount of nutrients available for utilization by the secretory cells.

As these actions may be brought about separately or in almost any combination and in varying degrees of intensity, it is seen that the problem of the influence of drugs on milk secretion is a complicated one and the fact that individual cows may vary somewhat in degree of susceptibility to drug action increases the complexity.

The problem is here treated with the view of determining the possibility of influencing the production of healthy cows and more particularly the percentage of fat in the milk, and thus ultimately the total yield of fat. In conducting this work the one or two day tests of the dairy cattle breed associations were kept in mind because it is not only in such tests that there would be the greatest opportunity and temptation to use drugs, but also fairly well recognized that a slight increase in production might be maintained for a few days by the use of drugs and yet be only temporary; and in addition continued drug administration would be more readily detected.

There is a long list of substances popularly reputed to have galactagogic effects—amongst these are the aromatics, fennel, anise, caraway, juniper berries, coriander, dill, pimpinella, calamus; the bitter stomachics, sulphur, the neutral salts, the antimony preparations, and many others—but distinction must be made between the use of drugs based on a knowledge of their physiological action and the use of those indicated by empirical teachings. The popular milk powders are compounded largely from the constituents just stated.

In this piece of work the drugs used include alcohol, castor oil, pituitrin, pilocarpine, physostigmine, aloes, calomel, nux vomica, Epsom salts and common salt, and these have been chosen in view of the fact that a knowledge of their physiological action would seem to indicate some possibility of their either directly or indirectly influencing the mammary gland. Some of the principal physiological effects noted upon the administration of these drugs are as follows:

Alcohol. When introduced into the general circulation alcohol produces a narcotic effect especially on the nervous tissues. It diminishes the efficiency of vital organs like the heart, blood-vessels and blood and their nervous mechanisms, with, in certain cases, an initial but transient stimulation. It interferes with body metabolism and especially with body oxidation. In addition, alcohol removes water from the tissues in large quantities, producing diuresis. This abstraction of water creates a physiological thirst which may result in a great craving for water or it may induce nausea with a consequent distaste for water.

Castor oil. Castor oil is not absorbed from the intestinal tract and in itself is not purgative. It is broken down in the alimentary canal with the production of ricinoleic acid and other substances which cause great irritation and subsequently bring about purging which not only carries off nutrients that might otherwise be utilized but also produces general depression.

Pituitrin. The extract of the pituitary body, one of the ductless glands, brings about a rise in blood pressure probably due to vaso-constriction and simultaneous heart stimulation though it has been found that the heart may not always be stimulated and

sometimes may even be weakened. It brings about an increase in urine elimination, perhaps by direct action on the renal epithelium, and it also stimulates the uterus and bladder.

Pilocarpine. The terminations of what are pharmacologically known as the autonomous nerves—the nerves serving the involuntary muscles but not passing through the sympathetic system—are stimulated by pilocarpine and consequently its administration may result in slowing of the heart, constriction of the bronchi, increased peristalsis, and hyper-secretion of the gastric, intestinal, salivary and sweat glands.

Physostigmine. Eserine or physostigmine acts very similarly to pilocarpine with the exception that it does not influence the secretions as markedly but stimulates peristalsis to a greater extent.

Aloes. The purgative action of aloes is due to the active principle aloin which stimulates peristalsis of the large intestine but does not influence the intestinal secretions. It is absorbed from the large intestine and is eliminated by way of the bowels, kidneys, and mammary gland. It sometimes causes diuresis; induces reflex irritation of the female pelvic organs, is an emmenagogue; and may be abortifacient.

Calomel. This is changed in the intestine to the grey oxide of mercury which has an irritating effect and so produces purging. Its action is chiefly on the small intestine and it is not absorbed. It is supposed to be a chologogue, the fact that it flushes out the small intestine probably inducing the bile to follow along though there is no direct action on the liver. Mercury, being a local irritant, may lead to increased secretion of the glands if the dose is sufficient to irritate without destroying the glandular protoplasm.

Nux vomica. When taken internally nux vomica, being a bitter stomachic, increases appetite and stimulates the secretion of the digestive juices. Therapeutic doses, after absorption, stimulate the great medullary centers, respiratory, vasomotor, and cardio-inhibitory, with a consequent rise in blood pressure and slowing of the heart. It is frequently given as a "tonic" but its only influence on nutrition is to send more blood to the tissues.

Epsom salts. The purgative action of magnesium sulphate is due to the fact that it not only prevents the absorption of water from the intestine but also abstracts water from the intestinal wall into the lumen.

Common salt. Sodium chloride is absorbed and does not cause purging, except when in large quantities, though it produces diuresis by abstracting water from the tissues.

PREVIOUS WORK

The study of the action of galactagogues on the human subject, goats and small laboratory animals has been fairly extensive, while their influence on the milk production of cows has received little attention.

Pituitrin. Even in the case of pituitrin, the most studied of all supposed galactagogues, very little work has been done with bovines. In endeavoring to find if there were any commercial benefits to be derived from treating cows with pituitrin, Gavin (1) used three methods for administering pituitary extract—by the mouth, subcutaneously, and intravenously—and he came to the conclusion that no increase in the daily milk yield or in the percentage of fat in the milk was obtained as a result of pituitrin administration. Hill and Simpson (2), on the other hand, found that the percentage of fat in cow's milk could be increased by administering pituitary extract intravenously but the yield of fat subsequently made a compensatory decrease.

Pilocarpine and physostigmine. According to Feser (3) the milk yield of cows is slightly increased by the injection of pilocarpine and eserine, while Frohner (4) got negative results with pilocarpine.

Aloes. It was found by Lanzoni (5) that the fat percentage in cow's milk was decreased by the administration of aloes.

Epsom salts. Lanzoni (5) found that the fat in cow's milk was increased after the administration of magnesium sulphate.

PLAN OF EXPERIMENT

The experimental work on which this paper is based was conducted in two parts, the preliminary series of experiments being carried out with only one cow, while in the second series three cows were used.

TABLE 1
Animals used

	SERIES			
	I	II		
Cow number.....	262	207	243	262
Breed.....	Grade Guernsey	Grade Holstein	Ayrshire	Grade Guernsey
Age, years.....	2.0	4.2	3.1	2.7
Weight, pounds.....	800	1280	840	900
Fresh, days.....	10	86	155	242
Previous lactations.....	0	2	0	0

The animals were all young, in good milking condition and free from derangements of health. They were kept open throughout the experiments.

The rations fed were practical ones suited to the needs of the animals and were such that no appreciable changes in the live weights of the animals took place.

In the first series the experimental periods were not always of the same length but in the second series the experimental periods were always of two days duration, while the check periods were each of four or five days. The experimental period was always taken as beginning with the milking next following the administration of the drug, the influence of which was being studied, and there were check periods before and after each experimental period.

The drugs were given either orally or subcutaneously.

TABLE 2
Administration of drugs

DRUG	SERIES	DOSAGE AND METHOD OF ADMINISTRATION
Alcohol.....	I	3 ounces of grain alcohol in a quart of water twice daily for two days
	II	Dose increased to 4 ounces
Castor oil.....	II	16 ounces in evening and 8 ounces in morning daily for two days
Pituitrin.....	I	2 drams of pituitary extract subcutaneously twice daily for four days
	II	Pituitary extract subcutaneously in doses of 1 dram in evening, 1 dram in morning and 2 drams at noon daily for two days
Pilocarpine and physostigmine....	I	2 subcutaneous injections $\frac{1}{2}$ hour apart in the morning and the same in the evening, daily for four days. Each dose contained 1 grain pilocarpine hydrochloride and $\frac{1}{2}$ grain physostigmine benzoate
	II	2 grains pilocarpine hydrochloride and $\frac{1}{2}$ grain physostigmine benzoate hypodermically three times daily for two days
Aloes.....	I	1 bolus containing 240 grains aloin, 60 grains calomel, and $\frac{1}{2}$ dram fluid extract of nux vomica; given in 1 quart of water
	II	Cows 207 and 243 each received 1 ounce aloes in a quart of water in the evening, while 262 was given 6 drams each evening on two consecutive days
Magnesium sulphate, sodium chloride and nux vomica	II	Each cow given twice daily for two days the following in a quart of water—8 ounces magnesium sulphate, 4 ounces sodium chloride, $1\frac{1}{2}$ drams powdered nux vomica

RESULTS

The results from the two series of trials will be considered together though tabulated separately.

TABLE 3

Average daily yields for cow 262 in first series of trials

DRUG	PERIOD	MILK	FAT	FAT
		<i>pounds</i>	<i>per cent</i>	<i>pounds</i>
Alcohol.....	Check	19.2	3.83	0.74
	Experiment	18.3	3.95	0.73
Pituitrin.....	Check	20.2	3.67	0.74
	Experiment	18.1	3.59	0.65
Pilocarpine and physostigmine.....	Check	19.4	3.64	0.71
	Experiment	19.2	3.99	0.77
Aloin, calomel and nux vomica.....	Check	19.4	4.01	0.78
	Experiment	15.9	4.80	0.76

In the trials of the first series with alcohol and aloin all periods were of four days each while in the other two trials the periods were of two days each.

On the whole the use of alcohol depressed rather than stimulated milk and butterfat production. The cow used in both experiments was remarkably uniform in her response to the drug. In all cases there was a slight decrease in total fat yield; and though there was a slight increase in fat percentage in all but one case, the single decrease that did occur was large enough to bring the average down to normal.

As the castor oil administered did not in any case induce purging or even a noticeable laxativeness it may be presumed that the cows were not overdosed, yet in every case there was a decrease in the percentage of fat in the milk and in some cases this was very marked even though the changes in milk yield were hardly appreciable. The total yield of fat also decreased in each case—on one occasion markedly. On the average there was no change in the milk yield but a decrease of about 10 per cent in the percentage and total yield of fat.

The cow used in both series of trials showed a decrease in milk production on both the occasions on which she was treated with pituitrin, while the other animals showed very slight changes

TABLE 4
Average daily yields for cows 207, 243, and 262 in second series of trials

DRUG	PERIOD	COW									AVERAGE		
		207			243			262			Milk	Fat	Fat
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat			
		<i>pounds</i>	<i>per cent</i>	<i>pounds</i>	<i>pounds</i>	<i>per cent</i>	<i>pounds</i>	<i>pounds</i>	<i>per cent</i>	<i>pounds</i>	<i>pounds</i>	<i>per cent</i>	<i>pounds</i>
Alcohol.....	Check	18.6	4.71	0.88	16.7	4.30	0.72	15.5	4.56	0.71	16.9	4.53	0.77
	Experiment	17.6	4.26	0.75	16.6	4.49	0.75	14.8	4.71	0.70	16.3	4.47	0.73
Castor oil.....	Check	18.3	4.57	0.84	17.8	3.95	0.70	16.4	4.10	0.67	17.5	4.21	0.74
	Experiment	17.7	3.76	0.67	18.2	3.65	0.67	16.5	3.97	0.66	17.5	3.79	0.66
Pituitrin.....	Check	16.7	4.98	0.83	17.6	4.55	0.80	16.7	4.44	0.74	17.0	4.65	0.79
	Experiment	17.1	3.63	0.62	17.9	3.89	0.70	15.5	3.74	0.58	16.8	3.76	0.63
Pilocarpine and physostigmine.....	Check	18.7	4.63	0.86	18.6	3.78	0.70	16.3	4.06	0.66	17.8	4.16	0.74
	Experiment	17.4	4.51	0.79	19.0	4.00	0.76	16.3	4.26	0.70	17.6	4.25	0.75
Aloes.....	Check	18.5	4.46	0.83	15.7	4.11	0.65	14.8	4.36	0.65	16.4	4.32	0.71
	Experiment	18.4	4.77	0.88	15.5	4.13	0.64	14.7	4.54	0.67	16.2	4.49	0.73
Magnesium sulphate sodium chloride and nuxvomica	Check	18.8	4.79	0.90	18.0	4.15	0.75	16.0	4.31	0.69	17.6	4.42	0.78
	Experiment	18.4	4.58	0.84	18.0	4.33	0.78	14.6	4.50	0.66	17.0	4.47	0.76

In the trials of the second series all experimental periods were of two days duration, the check periods for alcohol, castor oil and aloes were of four days each, and all other check periods were of five days each.

in milk yield. In every case there was a marked decrease in total yield of fat and throughout the second series of trials the administering of pituitrin resulted in a marked decrease of the percentage of fat in the milk. The average for the second series showed no appreciable change in milk yield but a decrease of about 20 per cent in percentage and yield of fat.

In the first series there was an appreciable increase in fat percentage and yield of fat when pilocarpine and physostigmine were administered and the cow used in this trial behaved very similarly in the second trial. One of the other cows in the second

TABLE 5
Percentage changes in production for first series of trials

DRUG	PER CENT CHANGE	MILK	FAT	FAT
		<i>pounds</i>	<i>per cent</i>	<i>pounds</i>
Alcohol.....	Increase	5	3	1
	Decrease			
Pituitrin.....	Increase	10	2	12
	Decrease			
Pilocarpine and physostigmine.....	Increase	1	10	9
	Decrease			
Aloin, calomel and nux vomica.....	Increase	18	20	3
	Decrease			

trial showed an increase throughout very similar to that shown by the cow used in both trials while the remaining animals showed a decrease in milk-yield and percentage and yield of fat. On the average the second series showed no appreciable changes.

The administration of aloes in no case produced purging. In the first series the aloes ball (containing aloin, calomel and nux vomica) induced a phenomenal decrease in milk production with a correspondingly high percentage of fat and on the whole the yield of fat was slightly reduced. In the second series there were no marked changes when the average yields were considered and even the individual variations were comparatively slight.

TABLE 6
Percentage changes in production for second series of trials

DRUG	PER CENT CHANGE	COW									AVERAGE		
		207			243			262					
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
		pounds	per cent	pounds	pounds	per cent	pounds	pounds	per cent	pounds	pounds	per cent	pounds
Alcohol.	Increase	5	10	15	1	4	4	5	3	1	4	1	5
	Decrease												
Castor oil.	Increase	3	18	20	2	8	4	1	3	1	10	11	
	Decrease												
Pituitrin.	Increase	2	27	25	2	15	13	7	16	22	1	19	20
	Decrease												
Pilocarpine and physostig- mine.	Increase	7	3	8	2	6	9	5	6	1	2	1	
	Decrease												
Aloes.	Increase	1	7	6	1	2	1	4	3	1	4	3	
	Decrease												
Magnesium sulphate sodium chloride, and nox vumica.	Increase	2	4	7		4	4	9	5	4	3	1	3
	Decrease												

The mixture of epsom salts, common salt and nux vomica given was accompanied by only slight changes in milk and butterfat yield.

RÉSUMÉ

1. The action of galactagogues on the production of cows has received little experimental study.
2. The results obtained from the use of galactagogues with dairy cattle and even laboratory animals are very conflicting.
3. The drugs used in the present study could not be relied on to induce an increase in the production of milk or in the yield or percentage of butterfat.
4. The most noted changes were decreases in the yield and percentage of butterfat brought about by pituitrin and castor oil.
5. Wide individual variations in their response to the drugs were shown by the cows.

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