KEY FACTORS TO STORING AND FEEDING QUALITY SILAGE

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1. Introduction

Preserving forage crops of high moisture content may present problems. When such materials are exposed to the air, microbial activity involving yeasts, fungi and bacteria takes place and causes high gaseous losses of dry matter. Over extended periods, the product becomes less palatable, frequently inedible and may become toxic. Aerobic deterioration of this sort may be minimized by rapid achievement and subsequent maintenance of anerobic conditions in storage. Even under anaerobic conditions, forages containing more than 74% moisture are subject to clostridia fermentation. These organisms break down sugars to butyrate and the protein fraction of the forage may be extensively degraded. As a result, the product becomes less palatable and of a poorer quality. Over 20% of the energy contained in the initial fermented carbohydrate can be lost during production of butyric acid.

2. The Harvesting Process

The quality of forage harvested is frequently inferior to that which was potentially available for harvesting due to rainy conditions, mechanical difficulties, labor problems or perhaps harvesting earlier than desirable. Likewise, the quality of the silage fed may not reflect the quality of forages ensiled due to conditions associated with improper fermentation such as poor packing. A number of studies have shown that chopping at ¼ to 3/8 inch increases dry matter storage per cubic foot 6-17%.

3. Phases of Silage Fermentation

Silage fermentation is frequently divided into five phases. Fiqure 1 shows these phases as well as outlining factors involved in silage fermentation. While phases 1, 2 and 3 are not clearly defined, phase 1 includes the final respiration of plant cells and the production of heat and carbon dioxide. Phase 1 is important since the stage is set for the production of acetic acid production and a lowering of the pH of the fermenting forage. As the pH becomes lower, acetic acid producing bacteria decrease rapidly. Thus, phase 2 develops into phase 3 with the initiation of lactic acid formation. The first few days also includes the settling of the forages in the silo with increases in rate of seepage, reaching its peak about the 4th or 5th day.

Table 1 Recommended Stages for Harvesting Certain Forages

Forage	Stage	Dry Matter
Forage Sorghum	Early Heading	28-35
Grain Sorghum	Late Dough	28-35
Small Grains	Early Heading	28-35
Corn	Medium to late Dent	28-35

The dry matter content of forages change rapidly in Florida during the harvesting process. If the harvesting period is extended over periods of more than 10 days to 2 weeks, the forage may become too dry, thereby reducing both the digestibility of the cellulose fraction of the forage and cause more difficulty in packing. If high DM silages (45% or more) are to be ensiled successfully, ensiling should be under gas tight conditions. Studies have shown that fermentation losses of high DM material in gas tight silos is about 6-10% as compared to 25-40% for bunker type silos.

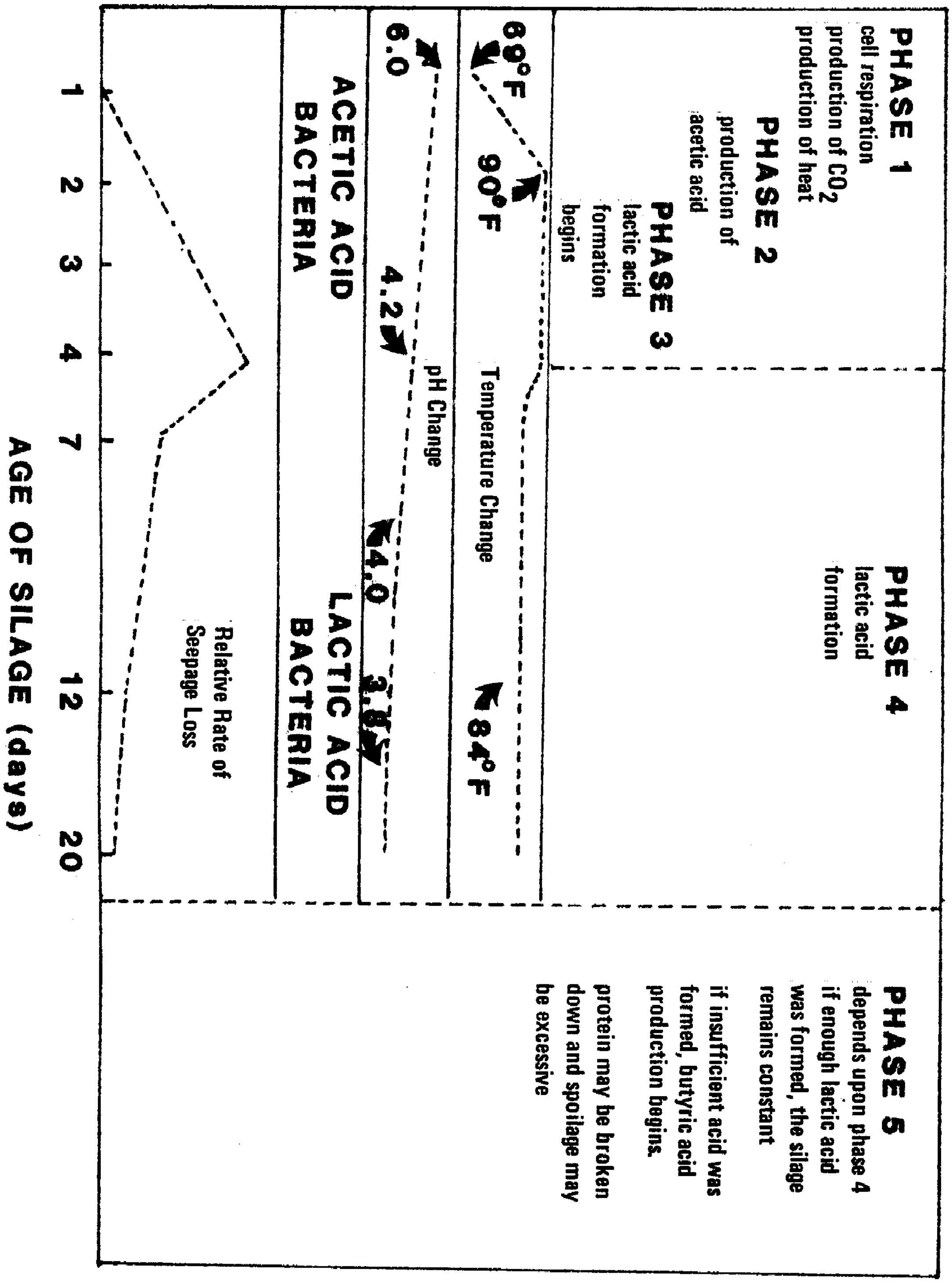
The effect of pH - The success of the ensiling process is closely associated with the pH of the fermented forage. The formation of acetic and lactic acids as well as the presence of ammonia and amines have some bearing on pH. Also, the buffering content of the forage ensiled has an influence on pH. In general, legume forages such as alfalfa and soybeans that have high buffering capacities are more difficult to ensile than corn and sorghum type forages. Such crops frequently require additives such as added acids or carbohydrates for good fermentation to occur. A pH of 3.5 to 4.5 is needed for storing good silage.

Carbohydrate Content of Forage - The carbohydrate content of forages varies considerably as shown in Table 2. In general, forages having less than 8% soluble carbohydrates are fairly low and may require the inclusion of additives to improve fermentation.

Table 2 The Water Soluble Carbohydrate (WSCHO) Content of Various Forage Crops

Crop	Stage of Maturity	Water	WSCHO (Dry Matter)
Alfalfa	Early Bloom	74.5	4.26
Rye Grass	Bloom	76.6	10.21
Soybeans	Pods formed	78.2	2.13
Corn	Milk stage	77.6	20.25
Oats	Heading	76.1	9.93
Sudan Grass	milk stage	70.4	13.41
Cowpen	Early bloom	79.0	6.55
Sorghum, grain	milk stage	78.0	18.50

Forages low in water soluble carbohydrates and/or high in moisture may be enhanced by the addition of dry feed in the form of ground grain, milling by-products or even chopped hay to increase the dry matter content.


PHASE 1
cell respiration
production of CO_2
production of heat
PHASE 2
production of
acetic acid
PHASE 3
lactic acid
formation
begins
PHASE 4
lactic acid
formation
PHASE 5
depends upon phase 4
if enough lactic acid
was formed, the silage
remains constant
if insufficient acid was
formed, butyric acid
production begins.
protein may be broken
down and spoilage may
be excessive
69°F
90°F
84°F
Temperature Change
6.0
4.2
4.0
3.8
pH Change
ACETIC ACID
BACTERIA
LACTIC ACID
BACTERIA
Relative Rate of
Seepage Loss
1
2
3
4
7
12
20
AGE OF SILAGE (days)

Phase 4 usually begins 3 to 5 days after ensiling and requires 15-20 days for completion. The success of silage making is determined during this phase. There is a gradual increase in lactic acid content until the acidity becomes great (3.8 to 4.2 pH) enough to stop further bacterial action.

Phase 5 represents the keeping quality over an indefinite period. If sufficient amounts of acetic and lactic acids were produced in the first four phases, phase 5 is merely a period during which the silage remains constant. An insufficient amount of acid leads to increased decomposition, reduced palatability, and possible spoilage.

4. Factors Affecting Silage Quality

There are a number of factors influencing the production of quality silage under the four phases of fermentation. Such factors are fermentation temperature, dry matter of the forage, the effect of pH, available sugars and/or carbohydrates, and rate of filling and packing.

Temperature - The optimum temperature of fermenting forage varies from 80° to 100°F. Temperatures outside those ranges results in poorer quality silage even though palatability may remain quite good. Underheated silage gives a drab green color, strong aroma, slimy soft tissues, insipid taste and a pH of about 5.0. Overheated silages, frequented referred to as "heat damage", ranges in color from brown to dark brown and has a charred hay or tobacco aroma. In contrast, properly fermented silage is light green to yellow in color, has a pleasant vinegray aroma, firm tissues, and a sharp acid taste indicative of pH less than 4.5.

Heat damage resulting from high temperatures in fermenting forages has received considerable discussion in recent years. The digestibility of protein has been found to be reduced in the presence of oxygen and high temperatures. The longer the heating the more the protein damage. Also, the rate of damage increases with temperature. Reductions in protein digestibility becomes quite serious above 120°F. Heating appears to not only decrease the availability of protein to the animal but also reduces the availability of carbohydrates. While excessively heated silages remain very palatable and are readily consumed by animals, a considerable proportion of their food value is lost. Temperatures of fermenting forages varying from 80 to 100°F should produce excellent silage.

Dry Matter (DM) Content - Forages high in dry matter present difficulties in packing. Unless good packing is accomplished, anaerobic conditions will be hard to maintain. The result is a higher temperature and pH in the forage. High moisture forage leads to greater seepage losses and possibly butyric acid formation. Seepage losses as great as 35% of the total nitrogen have been reported. Most data suggests and optimum dry matter of 28 to 35%.

The recommended stages for harvesting the major forages used in Florida are shown in Table 1.

The water soluble carbohydrates in forages are a readily available source of energy to initiate and sustain silage fermentation. In the presence of adequate carbohydrates, the lactic acid bacteria multiply rapidly which results in the production of lactic acid, acetic acid, CO_2 and ethanol as fermenting end-products. Inadequate amounts of WSCHO in silage crops may result from the type of forage, delayed or poor sealing of the silo, stage of growth, harvesting methods, weather and fertilization application.

5. Silage Additives and/or Preservatives

Additives can frequently be used to alter or improve fermentation. Forages such as corn and sorghums require no additives when properly harvested at the correct moisture content and properly ensiled. Once the acidity has reached a pH of about 4.0, the silage will keep for years providing it is protected from air and water. A few additives that have been used with varying degrees of success are discussed.

<u>Grains</u> - corn meal, citrus pulp and similar type energy ingredients may be added to forage (150-300 lbs/ton) to increase dry matter or provide more readily available carbohydrates for bacterial fermentation.

Special products - a number of products including poultry litter, wet brewers grains, and ground hay may be used to increase protein, dry matter, moisture and other alterations as desired or needed.

<u>Formic acid and Formaldehyde</u> - formic acid acidifies silage and results in improved lactic acid fermentation. Formaldehyde limits fermentation, particularly during the first few hours of ensiling, because of its bactericidal actions. These compounds usually result in improved digestibility of the forage crop to which they are applied. An additional benefit results from the maintenance of the integrity of the plant cell so that high-moisture silages will have less silo leakage. Formic acid and formaldehyde usually are added at about 0.4% of the green plant weight. Unfortunately, the cost has been nearly prohibitive in past years.

<u>Weak acids</u> - propionic acid is an excellent preservative for mold prevention. It has reduced temperature increases in high dry matter silages and helps conserve top silage in open silos. In experimental use, propionic acid has been the most effective preservative. In general, 0.5% to 1.0% of the green forage is applied depending on the moisture content. Benzoic acid and sodium benzoate are also effective against yeasts and molds in wetter materials. Acetic acid has preservative action but volatizes rapidly as heat increases. Because of the high cost of propionic acid, it is often recommended for application only in the last one or two loads of silage at the top of conventional silos to prevent top spoilage. It deserves consideration also in those portions of the silo that will be fed during hot weather since it will delay in-the-manger heating by 12 to 18 hours.

Andydrous ammonia - Treating corn silage with andydrous ammonia by the cold flow method prior to ensiling has been shown to be an effective way of adding NPN to corn silage. Most reports suggest the addition of 5 to 10 lbs of andydrous ammonia per ton with the preference of 10 lbs/ton. USDA studies at Beltsville using hard-dent corn forage treated with 7 lbs/ton of andydrous ammonia added at the blower showed an increase in protein dry matter from 9.06 to 11.19%. The fermentation resulted in more lactic acid production on ammonia treated corn silage (4.3 vs 3.21% in DM). Average daily gains for Holstein heifers in a 91 day growth trial were 1.9 lbs/day for untreated plus urea, vs. 2.3 lbs for the ammonia treated silage.

Enzymes - Products containing enzymes of Aspergillus oryzae and similar type products have been used in recent years with varying degrees of success. A variety of such products are available in the field even though little to no research data is available on such products. Work at the University of Florida showed a 2.1 lbs milk advantage when Aspergillus Oryzae product (GX) was used with sugarcane forage ensiled in a Silopress air-tight plastic bag and fed to Holstein cows. The sugarcane silage (as fed) and grain (18% protein) was fed evenly (1.1 ration) to all cows. Feed intake and milk yield (3.5% FCM basis) per day for the treated vs. control was: 47.1 and 46.7; and 57.0 and 54.9.

6. Using Different Types of Silos

Structures varing from silopress bags to large bunker silos are found in Florida. The tower or upright silo is less popular today due to the limited storage capacity it offers for feeding large numbers of cows.

Tower Silos - Very little seepage occurs from forage ensiled with less than 70% moisture in upright silos. Losses reported in dry matter have normally varied from 8-20%. The losses reported from properly harvested forages stored in gas tight silos are usually less than 10%. Greater losses are easily encountered where packing and sealing are poor.

Bunker and Trench Silos - Losses in horizonal silos have been observed as high as 30-50% in unsealed or poorly sealed silos. In recent years, the applying of plastic film has greatly reduced storage losses. Limited work indicates that low-moisture silage may be preserved at efficiencies approaching those found in conventional tower silos. Average losses from 70% moisture forage stored in well-packed bunker sealed silos is about 10-20%.

7. Covering the Silos

In recent years a number of Florida dairymen have harvested large quantities of forage and stacked on the ground. In most cases, no attempt was made to cover or seal the forage to prevent exposure and spoilage losses. Air which gets into the silage mass because of insufficient packing causes spoilage due to heating and poor fermentation. Stacks entirely enclosed in plastic coverings from which the air has been pumped (vacumm stacks) have less spoilage than regular stacks.

Covering the bunker or horizontal silo is important due to the large exposed surface area. Covering with plastic held down with old tires has been a common practise. Silage removed from properly packed and covered horizontal silos is comparable to silage removed from upright silos. In one California trial, recovery of preserved corn silage was 74.2% in a small experimental covered silos vs compared to 58.1% in uncovered silos. In the same study the temperature during the first month at the one-foot depth varied from 120° to 133°F in the uncovered silage as compared to 101° to 68°F for the covered. Silage recovered or weighed-out from the covered silo was 74% as compared to 58% for the uncovered silo. While these figures are slightly exaggerated due to the smaller bunker silos, field results indicate similar but lower losses.

8. Removal of Silage From Silos

It is important that care be used in removing silage from silos, especially bunker type silos to keep secondary fermentation from occuring. Secondary fermentation involves aerobic deterioration of silage exposed to air and especially silage that has been loosened by mechanical processes. Noticeable signs are surface heating, slimy feel, formation of mold and ammonia odor. As a result, the pH increases rapidly with significant losses in water soluble carbohydrates, short-chain organic acids and starch and structural carbohydrates. On a hot day, the losses in nutrients of the lossened silage could exceed 50%.

9. Feeding Silage to Dairy Cows

Silage is a succulent and palatable feed that may be fed in fairly large quantities to dairy cows. The amounts fed in most Florida herds varies from 40 lbs daily per cow to high herds and 60 lbs/cow to the lower producing herds. Two grain mixtures may be needed if the amounts of silage are varied in greater amounts since protein becomes limiting. The idea is to provide a balanced ration for all levels of milk production.

The two common approaches used in feeding silage includes: 1) feeding it as a separate feed and 2) mixing the silage with the concentrate to form a complete feed. The latter system is most popular and has certain advantages. The greatest advantages include reduced separation, assures intake of all ingredients in desired proportions and improves the intake of less palatable ingredients.

The composition of several silages used in Florida are shown in Table 3.

Table 3. Average Silage Analysis 1967-80

Forage	Samples	Moisture	CP	Fiber	TDN	ENE
Corn	300	71.0	2.4	7.0	20.1	17.5
Grass - Callie	7	65.0	2.7	10.6	19.0	15.9
Grass - Coastal Bermuda	5	66.0	2.8	12.1	18.1	14.0
Grass - Pangola	25	71.3	2.2	10.0	15.1	12.0
Mixed Grasses	45	71.6	2.5	9.7	15.4	11.6
Pearl Millet	8	74.5	1.5	8.2	11.9	10.0
Small Grain - Oat	6	64.0	3.0	10.4	18.6	17.6
Small Grain - Rye	5	66.0	3.2	9.5	17.0	15.0
Sorghum - Grain	75	70.2	2.2	7.9	18.0	15.0
Sorghum - Sudan Hybrid	50	75.5	2.1	7.4	13.2	10.0

Information in Table 4 shows that an 18% commerical feed blended with the listed amounts of corn silage would meet the requirements of dairy cows.

Table 4. Feeding Corn Silage to Dairy Cows

Milk Production (lb)	30	40	50	60	70	80
Feeding program (lb)						
Silage, corn (20% TDN, 2.5% CP)	60	60	50	50	40	40
Grain needed (18% CP, 70% TDN)	12	15	22	26	33	38

Dairymen using mixer wagons and purchasing ingredients frequently blend the ingredients together in a manner similar as outlined in Table 5. The amounts are multiplied according to the number of cows placed in the group.

Table 5. Feeding Corn Silage to High Producing Cows-70# milk

Ingredients	lbs	CP	TDN	Ca	Phos
		(lb)	(lb)	(lb)	(lb)
Corn Silage	40	1.00	8.00	.036	.020
Soybean meal (44)	9.5	4.18	7.41	.019	.057
Soy hulls	4	.43	2.80	.015	.006
Citrus pulp	4	.25	2.88	.060	.004
Corn meal	12	1.03	9.60	.002	.036
Masonex	2	----	1.20	.010	----
Mineral (15% Ca, 8% P)	.7	----	----	.105	.056
		6.89	31.89	.247	.179
Requirements		6.86	31.00	.230	.165

A flexible, ease of handling and economical system for feeding silage should be planned and developed prior to growing the forage. Once the system is agreed upon and developed, the silage may be offered easily to the cows.

10. Economic Considerations in Feeding Silage

The economics for growing and feeding silage in Florida have become more favorable in recent years due to the high cost of by-product roughages. Information in Table 6 shows the value of corn silage used in combination with a grain supplement versus a complete feed. Fiqures shown are based on dairy cows consuming 50 lbs of corn silage and adequate grain to meet the requirements for 50 lbs of 3.5% milk versus the consumption of a complete feed to meet the requirements for a similar amount of milk.

The information in Table 6 is quite simple and should be used only as a guide in estimating the value of good quality corn silage at the feed bunk rather than in the silo. As an example, if a complete feed costs $160 per ton and an 18% grain supplement costs $200 per ton, the good quality corn silage would be worth approximately $40.95 per ton mixed and delivered to the feed bunk.

Table 6

THE FEEDING VALUE OF CORN SILAGE PER TON BASED ON USING A COMPLETE FEED VERSUS AN 18 - 20% GRAIN SUPPLEMENT TO USE WITH CORN SILAGE

Cost of 18% - 20% Protein Grain Supplement	COST OF COMPLETE FEED PER TON*										
	$125	$130	$135	$140	$145	$150	$155	$160	$165	$170	$175
$140	$37.30	$41.20	$45.10	$49.00	$52.90	$56.80	$60.70	$64.80	$68.50	$72.40	$76.30
$145	$35.15	$39.05	$42.95	$46.85	$50.75	$54.65	$58.55	$62.45	$66.35	$70.25	$74.15
$150	$33.00	$36.90	$40.80	$44.70	$48.60	$52.50	$56.40	$60.30	$64.20	$68.10	$72.00
$155	$30.85	$34.75	$38.65	$42.55	$46.45	$50.35	$54.25	$58.15	$62.05	$65.95	$69.85
$160	$28.70	$32.60	$36.50	$40.40	$44.30	$48.20	$52.10	$56.00	$59.90	$63.80	$67.70
$165	$26.55	$30.45	$34.35	$38.25	$42.15	$46.05	$49.95	$53.85	$57.75	$61.65	$65.55
$170	$24.40	$28.30	$32.20	$36.10	$40.00	$43.90	$47.80	$51.70	$55.60	$59.50	$63.40
$175	$22.25	$26.15	$30.05	$33.95	$37.85	$41.75	$45.65	$49.55	$53.45	$57.35	$61.25
$180	$20.10	$24.00	$27.90	$31.90	$35.70	$39.60	$43.50	$47.40	$51.30	$55.20	$59.10
$185	$17.95	$21.85	$25.75	$29.65	$33.55	$37.45	$41.35	$45.25	$49.15	$53.05	$56.95
$190	$15.80	$19.70	$23.60	$27.50	$31.40	$35.30	$39.20	$43,10	$47.00	$50.90	$54.80
$200	$13.65	$17.55	$21.45	$25.35	$29.25	$33.15	$37.05	$40.95	$44.85	$48.75	$52.65
$205	$11.50	$15.40	$19.30	$19.30	$23.20	$27.10	$34.90	$38.80	$42.70	$46.60	$50.50
$210	$ 9.35	$13.25	$17.15	$21.05	$24.95	$28.85	$32.75	$36.65	$40.55	$44.45	$48.35
$215	$ 7.20	$11.10	$15.00	$18.90	$22.80	$26.70	$30.60	$34.50	$38.40	$42.30	$46.20
$220	$ 5.05	$ 8.95	$12.85	$16.75	$20.65	$24.55	$28.45	$32.35	$36.25	$40.15	$44.05
$225	$ 2.90	$ 6.80	$10.70	$14.60	$18.50	$22.40	$26.30	$30.20	$34.10	$38.00	$41.90
$230	$ 0.75	$ 4.65	$ 8.55	$12.45	$16.35	$20.25	$24.15	$28.05	$31.95	$35.85	$39.75

*Complete Feed contains 13% CP, 64% TDN, 18% fiber, 0.7% ca and 0.4% phos.