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BRADY CROP COOKER
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CONTENTS

I. SOYA BEAN PROCESSING WITH BRADY CROP COOKER

Soya bean production in Guatemala and other Latin American countries is increasing with the producers intending to use the majority of the beans for animal feed. Even though much work has been done in the United States to process whole soybeans with the Brady, it was considered desirable to obtain this experience locally so as to best advise potential users of the steps to be followed.

For the first study, soya beans of the Improved Pelikan variety grown in Guatemala in 1975 were used. The material was processed according to the conditions indicated in Table 1. It was processed three times as shown at temperatures of 285, 320 and 335° F for each extrusion, respectively. After each extrusion, samples were taken for chemical analysis, trypsin inhibitor activity and biological testing with rats.

The chemical composition of the samples produced and reference materials are shown in Table 2. No explanation is available for the low fat value in the whole soybeans before processing (16.5%) which was repeated, as well as for the higher one in the sample cooked by autoclaving. The extruded samples averaged about 19.5% fat and around 40% protein. Trypsin inhibitor activity decreased with respect to the number of times the material was extruded. It can be noted that the temperature of extrusion was 285° for the first pass giving a TUI value of 24.8 which dropped to 1.6 for the sample processed three times at a temperature of 335°.

The biological evaluation of the products is shown in Table 3. It is shown that weight gain improved with increasing the number of extrusions of the material. This weight gain was highly correlated with trypsin inhibitor activity. However, none of the samples had the protein quality of soybean meal. Increasing the number of passes through the extruder also increased the acceptability of the product as judged by increased food intake.

These studies are being repeated to confirm the results observed, since they now suggest the Brady is not cooking the whole soybeans completely.

TABLE 1
PROCESSING CONDITIONS OF WHOLE SOYBEANS

Pass No.	Cone apperture	Feeding setting	Yield lb/hr	Temperature -°F
1	1/2 turn	2	1,064	285
2	3 1/2 turn	2	614	320
3	4 1/2 turn	2	665	335

TABLE 2
CHEMICAL COMPOSITION OF SAMPLES (%) AND TRYPSIN INHIBITOR ACTIVITY

Sample	Moisture	Fat	Protein	TUI/ml
Whole soybean	9.2	16.5	39.2	46.9
Cooked in autoclave	10.2	22.5	41.0	9.8
Soybean meal	10.2	0.8	47.3	10.2
Extruded once	4.6	19.2	39.7	24.8
Extruded twice	4.1	19.5	39.7	9.6
Extruded three times	2.2	19.9	41.6	1.6

TABLE 3
BIOLOGICAL EVALUATION OF PRODUCTS

Sample	Ave. wt. gain, g *	PER	Feed Efficiency
Whole soybean	19	0.78	11.7
Cooked soybeans	41	1.71	5.8
Soybean meal	47	1.99	5.3
Extruded once	25	1.01	9.2
Extruded twice	29	1.19	8.0
Extruded three times	44	1.63	5.6
Casein	67	3.15	3.1

* 14 days

II. PROTEIN QUALITY OF A CORN/WHOLE SOYBEAN MIXTURE PROCESSED BY A SIMPLE EXTRUSION COOKER

Previous studies showhed that whole soybean and whole corn protein mixed in a weight ratio of approximately 3 to 7 gave a food of a higher protein quality than that of each individual component as shown in Table 1. It was found that the mixture of 72 grams of whole corn and 28 grams of soybeans gave a PER of 2.54 at the 10% protein level. This mixture contains around 18% protein and 10% fat, therefore it is a food with a relatively high energy content. The process to produce such foods was an alkaline wet cooking method, which resulted in a nutritionally adequate and acceptable product: However, the process, although feasible, is too expensive.

Since such a mixture is not stable when blended raw, simple processing techniques were sought. One opportunity was offered by simple extrusion cooking equipments, of which the Brady Extruder is an example. Preliminary results on its potential are shown in Table 2. In this case, the 70/30 corn/soybean mixture was toasted, alkaline processed, and extruded-cooked in a Brady and Wenger X-25 extruder, respectively. The protein quality values show that the extruded product and the alkaline processed product were of equal nutritive value. In view of these results the objective was to find the best physical form of the ingredients and the processing conditions to produce a food of the quality needed for human consumption, using simple extrusion cooking equipment.

MATERIALS AND METHODS

The soybeans and corn utilized for these studies were grown either at the INCAP experimental farm or in the lowlands of Guatemala.

Batches of four hundred kilograms of whole corn were ground in a hammer mill to three particle size, and whole soybeans were ground to a standard particle size. The distribution of particles in each batch, either of corn or soybeans, was obtained by weighing 5 -one hundred gram samples and screening them through 20, 40, 60, 100, 140, 150 mesh screens. The amount passing through each screen was recorded and the distribution calculated. These results are shown in Table 3. The intermediate particle size corn is not shown;

however, the percentage size distribution was similar to the coarse particle size, with a somewhat lower percentage in the 20 mesh screen. Table 2 shows the particle size distribution of the fine and coarse grind mixtures which were utilized for the studies to be described.

With each particle size of corn two hundred kilograms batches of the corn/soybean blend in a 70/30 weight ratio were mixed and a sample taken for chemical analysis. Water was added to the raw mixture when the run with the extrusion cooker called for such treatment. The amounts of water were increased from about 14% to 18%. The addition was done in a blender.

The mixture was then processed with the extruder and after 20 minutes of operation a 50 kg. sample was taken. The conditions of extrusion were recorded. When the sample cooled to room temperature its density was measured by weighing the amount placed in a one-liter container. This was done 5 times per sample.

Each sample was analyzed for protein and fat content using the AOAC methods of analyses, and for trypsin inhibitors activity by the method of Kakade & Evans. The samples were analyzed also for water absorption and retention. The rest of the samples were used for protein quality as - says using the PER method.

RESULTS

Table 5 summarizes the results obtained in the first series of experimental runs with the Brady Extruder, in which three corn particle sizes were tested without any previous sample treatment. Extrusion of the 70/30, corn/soybean mixture decreased trypsin inhibitors activity, and it appears that more was destroyed when the mixture extruded contained corn of a large or coarse particle size.

Water retention increased in the extruded product for each particle size. The results also show that in the cooked extruded product, higher water retention was obtained using the coarse particle size corn. Water absorption was increased also by extrusion to about the same extent for the three particle sizes. The weight per unit volume was decreased by extrusion. From these results there appears to be an inverse relationship between particle size of corn and weight of extruded product per unit volume. This data indicates that significant expansion took place upon extrusion. Finally, protein quality, as measured by PER, was increased by extrusion but there was no apparent relationship to corn particle size. Table 6 shows the effect of the addition of water and heat application before extrusion on the weight of extruded product per unit volume. A thermic treatment for 8-10 minutes decreased weight per liter from 184 to 149, while the application of both heat and moisture decreased weight per liter even further. This means the product has a relatively high expansion rate. Such studies were not carried out with the other two corn particle sizes; however, the same results would probably have taken place. The water and heat treated samples had no measurable trypsin inhibitor activity.

In a second series of experimental runs, fine and coarse particle sized corn was used. Experimental conditions are shown in Table 7. The fine particle size corn was adjusted in the mixture with soybean to three moisture levels, 13.6, 17.4 and 21.4%, respectively. In an additional run 0.25% lime was added and the moisture adjusted to 17.8%. The coarse grind mixture was adjusted to 23.4% moisture. Table 8 shows the specific volume and water absorption of the extruded products. Specific volume increased with respect to water addition before extrusion in the fine grind corn samples. The addition of lime or the coarse particle sized corn tended to decrease specific volume of the extruded product at comparable levels of moisture in the mixture. Water absorption of the extruded product was higher for samples of the mixture with more than 17% moisture than for samples with 13.6% moisture.

Table 9 summarizes the level of trypsin inhibitors activity and the quality of the protein of the extruded product. Moisture level in the blend before extrusion helped decrease trypsin inhibitor activity, which dropped from a value of 7.2 in the raw product to 1.4 when the moisture level was 21.4%.

Average weight gain showed a direct relationship to moisture level in the blend before extrusion, and PER increased from the raw to the extruded product, irrespective of moisture content. Since no change in PER was observed, extrusion probably increased the palatability of the product, since rats gained more weight.

These results are graphically described in Figure 1.

DISCUSSION

The Brady Extruder is a simple machine which was developed to process soybeans on the farm . Several tests have been conducted with it to process starch, in order to increase its utilization by various farm animals. There has been recent interest in testing the machine for the production of high protein foods in developing countries.

Since the machine is not easily controlled, and there is need to produce food products of the highest quality possible for human consumption, some standardization is essential.

In the studies carried out in this report, two factors were studied. The first was the particle size of the material going into the machine, and the second was the addition of water. Even though some tendencies in the quality of the product were observed with respect to particle size of the material, the results show no real trend. However, the results suggested that the intermediate or coarse grind was better because there was less problem in running the machine without getting it jammed.

On the other hand, the addition of water was definitely of benefit, which is really not a new finding, since it is well known that to destroy or inactivate trypsin inhibitors in soybeans, moisture is essential. Thefore, it is recommended that the material should contain at least 17% moisture before extrusion with the Brady. To accomplish this, a steam jacketed horizontal blender is being adapted to the Brady in our laboratories, to be able to add and mix water with the solids and to apply a thermic treatment if considered necessary.

The results show that the Brady Crop Cooker can play a useful role towards the solution of the nutrition problem facing underdeveloped societies, since it is a simple inexpensive machine with a relatively good output per unit time. Because of these characteristics, many units could be installed in a country provinding, therefore, a better and cheaper distribution of the product. It is necessary however, to carry out additional studies to standardize processing conditions and to make sure these will result in high quality products for human feeding.

TABLE 1
PROTEIN AND FAT CONTENT AND PROTEIN VALUE OF VARIOUS MIXTURES OF CORN AND SOYBEANS*

Mixture **		Content of		Ave. wt.	
Corn %	Soybean %	Protein %	Fat %	gain, g	PER
100	0	9.9	4.5	12	0.69
79	21	16.9	8.9	81	2.08
72	28	17.6	10.3	91	2.54
62	38	18.1	11.3	99	2.37
0	100	40.0	25.6	101	2.03
Casein		–	–	120	2.87

* Bressani et al <u>J</u>. <u>Food Sci</u>. 39: 577, 1974
** Mixtures processed by alkaline cooking

TABLE 2
PROTEIN QUALITY OF A CORN/SOYBEAN BLEND (70/30) PROCESSED BY DIFFERENT TECHNIQUES

Process	Average weight gain, g	PER
Raw	20 ± 3.2	1.03
Toasted	-2 ± 1.0	–
Alkaline cooked	82 ± 5.7	2.60
Extrusion *	82 ± 5.7	2.60
Extrusion	78 ± 5.2	2.43

* Brady extruder

TABLE 3
PARTICLE SIZE DISTRIBUTION OF CORN AND SOYBEAN

Particle size	Soybean %	Corn	
		Fine grind %	Coarse grind %
20	53.06	29.26	43.78
40	19.74	28.82	23.84
60	15.84	23.54	19.22
100	10.54	15.96	11.42
140	0.78	1.76	1.22
150	0.02	0.48	0.52
Fines	0.02	0.18	0.00
Total	100.00	100.00	100.00

TABLE 4
PARTICLE SIZE DISTRIBUTION OF CORN AND SOYBEAN MIXTURE (70/30)

Particle size mesh	Fine grind %	Coarse grind %
20	47.52	57.56
40	24.52	19.25
60	18.14	15.73
100	9.46	6.74
140	0.34	0.47
150	0.02	0.25
Fines	0.00	0.00
Total	100.00	100.00

TABLE 5

PHYSICAL AND NUTRITIONAL CHARACTERISTICS OF MIXTURES OF CORN AND SOYBEANS OF DIFFERENT PARTICLE SIZE BY THE BRADY EXTRUDER

Description of sample	TUI/g	Water Retention, %		Water Absorption, %		g/lt	PER*
		Raw	Extruded	Raw	Extruded		
Raw	14.1	-	-	2.71	-	638.6	0.94
Small particle size	11.1	3.00	510	2.55	4.64	183.9	2.60
Intermediate size	8.5	4.50	827	2.77	4.57	191.2	2.41
Coarse size	7.5	7.20	1013	2.82	5.12	206.5	2.49
Casein	-	-	-	-	-	-	3.15

* 14 days

TABLE 6

EFFECT OF MOISTURE ADDITION AND HEATING OF A SOYBEAN/CORN MIXTURE BEFORE EXTRUSION ON DENSITY OF EXTRUDED PRODUCT

Corn particle size	Time before extrusion Water	Heat	Time	Weight of extruded product g/lt
Small	none*	no	-	183.9
	none*	60-65 °C	8-10 min	149.0
	4% **	60-65 °C	8-10 min	56.8
Intermediate	none*	no	-	191.2
Coarse	none*	no	-	206.6

* Moisture content, 14%

** Moisture content, 18%

TABLE 7
CONDITIONS OF EXTRUSION OF THE VARIOUS SAMPLES

Sample	% H_2O	Input feeding rate, rpm	Cone aperture inches	Temperature °F	Output rate kg/ hr
Fine grind	13.6	32	0.01	290	717
Fine grind	17.4	32	0.02	290	680
Fine grind	21.4	32	0.02	290	652
Fine grind*	17.8	32	0.02	290	454
Coarse grind	23.4	32	0.02	290	573

* With 0.25% $Ca(OH)_2$ added

TABLE 8
CHARACTERISTICS OF THE EXTRUDED PRODUCT

Sample	% H_2O	Specific volume cm^3 / g	Water absorption
Fine grind	13.6	1.52 ± 0.05	3.97
Fine grind	17.4	2.69 ± 0.10	5.34
Fine grind	21.4	3.27 ± 0.21	4.83
Fine grind*	17.8	2.09 ± 0.07	5.03
Coarse grind	23.8	3.06 ± 0.25	4.78

* With 0.25% $Ca(OH)_2$ added

TABLE 9

NUTRITIONAL CHARACTERISTICS OF EXTRUDED PRODUCTS

Sample	% H_2O	TUI/ml	Average weight gain, g	PER
Fine grind	13.6	6.06	69	2.00
Fine grind	17.4	3.44	77	2.18
Fine grind	21.4	1.38	84	2.16
Fine grind*	17.8	2.90	96	2.22
Coarse grind	23.8	-	92	2.30
Raw product	-	7.18	18	0.77
Casein	-	-	112	2.50

* PER values adjusted to a casein value of 2.50

III. EXTRUDED AND TOASTED WHOLE SOYBEANS IN RATIONS FOR GROWING CHICKS

As is well known, soybean meal is the main source of protein in rations for growing chicks in developed and underdeveloped countries. In many countries, however, soybeans are not grown, and the meal has to be imported from soybean-producing countries increasing thus the cost of the ration and, consequently, the price of poultry.

The extrusion process opens the possibility of using whole soybeans as a source of both protein and energy in rations for chicks, provided that the process involved destroys effectively the antiphysiological factors present in soybeans. Among these, hemagglutinins, trypsin inhibitors and goitrogens are the most important. All of the above-mentioned factors are, however, destroyed by treatment with steam under pressure. Dry heat treatment, on the other hand, does not affect these factors to a large extent.

The purpose of the present study was to determine the effect of substituting extruded and toasted ground soybeans for soybean meal in a ration for growing chicks. The extrusion process was as follows: The seeds were moistened 16% and then were extruded twice in a Brady Crop Cooker extruder. The first extrusion was done with an initial temperature of 340 °F, the final temperature was 280° F and the cone aperture approximately 0.01 inches. The second extrusion was carried out with an initial temperature of 340 °F, final temperature 250 °F, and the same cone opening as the first. The extruded product was ground and incorporated into chick rations.

Other batches of soybeans were toasted for 10 minutes at 180 – 200 °C after increasing the moisture content of the seeds to 16%. The toasting procedure was repeated once, the product ground and then incorporated into chick rations. The composition of the rations is shown in Table 1.

All rations were isocaloric and isoproteic and soybean meal was used as control when either corn or sorghum constituted the cereal.

Day-old male chicks of the Vantress strain, distributed in groups of 8, were housed in heated batteries. Each group had a replicate(control group), with a total of 16 animals per treatment; rations and water were supplied ad-libitum and the animals weighed every week. At the end of five weeks the protein content of the rations was decreased from 21 to 18 per cent and all were kept isocaloric; at this time too, the two replicates were pooled and the chicks moved to floor pens.

The experiment is still underway, but the results for the 7th week are shown in Table 2. As can be seen neither extruded nor toasted soybeans supported as good a growth as soybean meal. Furthermore, mortality was higher for the extruded soybean fed groups than for the control group or the toasted soybeans group. This was not a reflection of feed intake since intake was not influenced by the kind of soybean product used in the rations. These results seem to indicate that the conditions of extrusion did not completely destroy the antiphysiological factors present in the seeds. The absence of mortality in the groups fed the toasted soybeans indicates that although the antiphysiological factors responsible for mortality were more thoroughly destroyed than with the extrusion process, the high temperature used may have had a deleterious effect on amino acid composition as judged by the lower weight gains in this group, in spite of their increased feed consumption.

The data indicate that the extrusion conditions used for processing soybeans for chick feeding should be studied more thoroughly.

TABLE 1
COMPOSITION OF EXPERIMENTAL RATIONS

Ingredients	1	2	3	4	5	6
Soybean meal	33.34	–	–	33.34	–	–
Extruded soybeans	–	44.76	–	–	44.76	–
Toasted soybeans	–	–	50.92	–	–	50.92
Ground corn	52.11	49.44	44.38	–	–	–
Ground sorghum	–	–	–	52.11	49.44	44.38
Bone meal	2.10	2.10	2.10	2.10	2.10	2.10
Calcium carbonate	1.50	1.50	1.50	1.50	1.50	1.50
Iodized salt	0.45	0.45	0.45	0.45	0.45	0.45
DL-Methionine	0.10	0.10	0.10	0.10	0.10	0.10
Vegetable oil	9.85	1.10	–	9.85	1.10	–
Premix Pfizer	0.55	0.55	0.55	0.55	0.55	0.55
Total	100.00	100.00	100.00	100.00	100.00	100.00
Protein % (Calculated)	21.0	21.0	21.0	21.0	21.0	21.0
Fat, % (Calculated)	12.8	12.8	12.8	12.8	12.8	12.8

Analysis: Extruded soybeans: protein, 37%; ether extract: 21.4%; TUI (Trypsin Units Inhibited) : 5.5%

Toasted soybeans: protein: 33.4%; ether extract: 21.3%; TUI: 14%

TABLE 2
PERFORMANCE OF CHICKS FED EXTRUDED OR TOASTED SOYBEANS AND SOYBEAN MEAL FOR SEVEN WEEKS

Treatment	Weight gain g	Feed consumption kg	Mortality %
Control * – Corn	1075	30.54	6
Extruded soybeans – Corn	1032	28.42	25
Toasted soybeans – Corn	895	32.52	0
Control * – Sorghum	1035	30.39	6
Extruded soybeans – Sorghum	941	29.54	12
Toasted soybeans – Sorghum	972	35.64	0

* Soybean meal

IV. EXTRUSION OF A 60:40 CORN:SOYBEAN MIXTURE

MATERIALS

a. Ground corn (60 mesh)

b. Dehulled soybeans

METHODS

Corn and soybeans were mixed in a 60:40 ratio and then extruded, using a cone opening 0.005 inches wide (1/4 turn of the crank), while the feeding rate was varied to 2, 1.9, 1.8 and 1.6 in the scale of the control valve. The following data were recorded: temperature of extrusion, mass flow of the extruded material, specific volume, and moisture and trypsin inhibitors content.

RESULTS AND DISCUSSION

Results are shown in Table 1 and Figures 1 to 8. Figure 1 shows that temperature of extrusion is inversely proportional to feeding rate. This is explained easily since it is general knowledge that the longer the material remains in contact with the hot surface of the extruder, the higher will be the temperature reached. It is also evident that the lower the flow of material inside the extruder, the longer it stays in the machine.

Figure 2 shows that there is an inverse relationship between the specific volume of the material and the feeding rate. Specific volume is an indicator of the degree of expansion of the material and it increases as the temperature rises, as can be seen in Figure 3; the higher the rate of feeding, the lower the temperature of extrusion and the specific volume. The dependence of expansion on temperature could be due to the fact that at high temperatures, evaporation of water and gelatinization of starches is more violent.

The relationship between the moisture content of the extruded product and the feeding rate is illustrated in Figure 4 where it can be noted that the percent of moisture content is a direct function of the feeding rate. This is due to the fact that the lower the feeding rate, the higher the temperature and the rate of evaporation of water, which results in a lower moisture content of the extruded product. These relationships can be seen in Figure 5.

The feeding rate conditions the flow of the extruded material as shown in Figure 6. This is logical, since if one operates at a constant cone opening, the flow of the material will be conditioned by the feeding rate and resistance will be constant.

Trypsin inhibitor content depends on feeding rate if one operates at a constant cone opening, as can be seen in Figure 7. The higher the rate of feeding, the lower the extent of destruction of these toxic factors. The dependence of extrusion temperature on feeding rate explains this fact, and Figure 8 shows that as the temperature is increased, the trypsin inhibitors content is decreased.

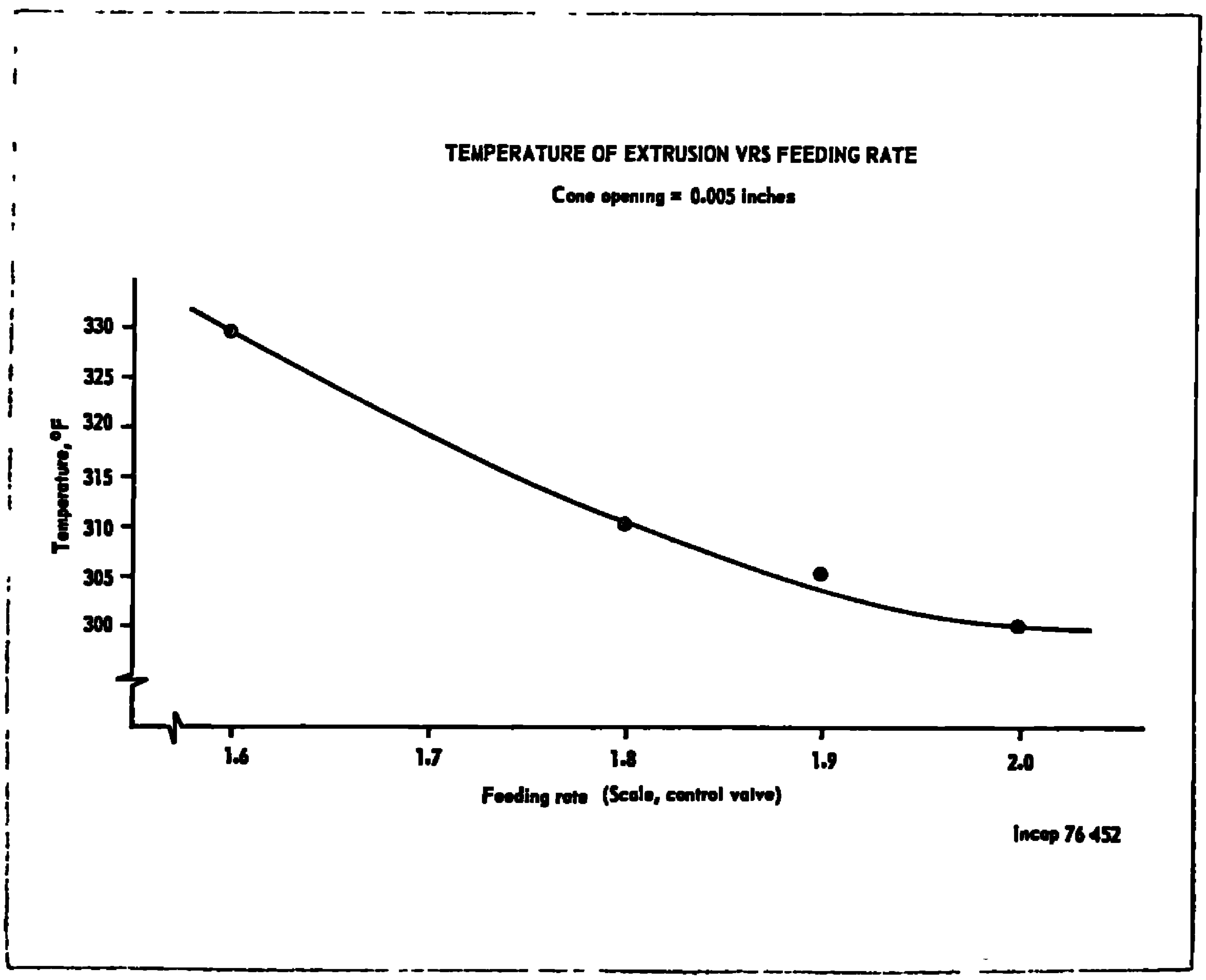
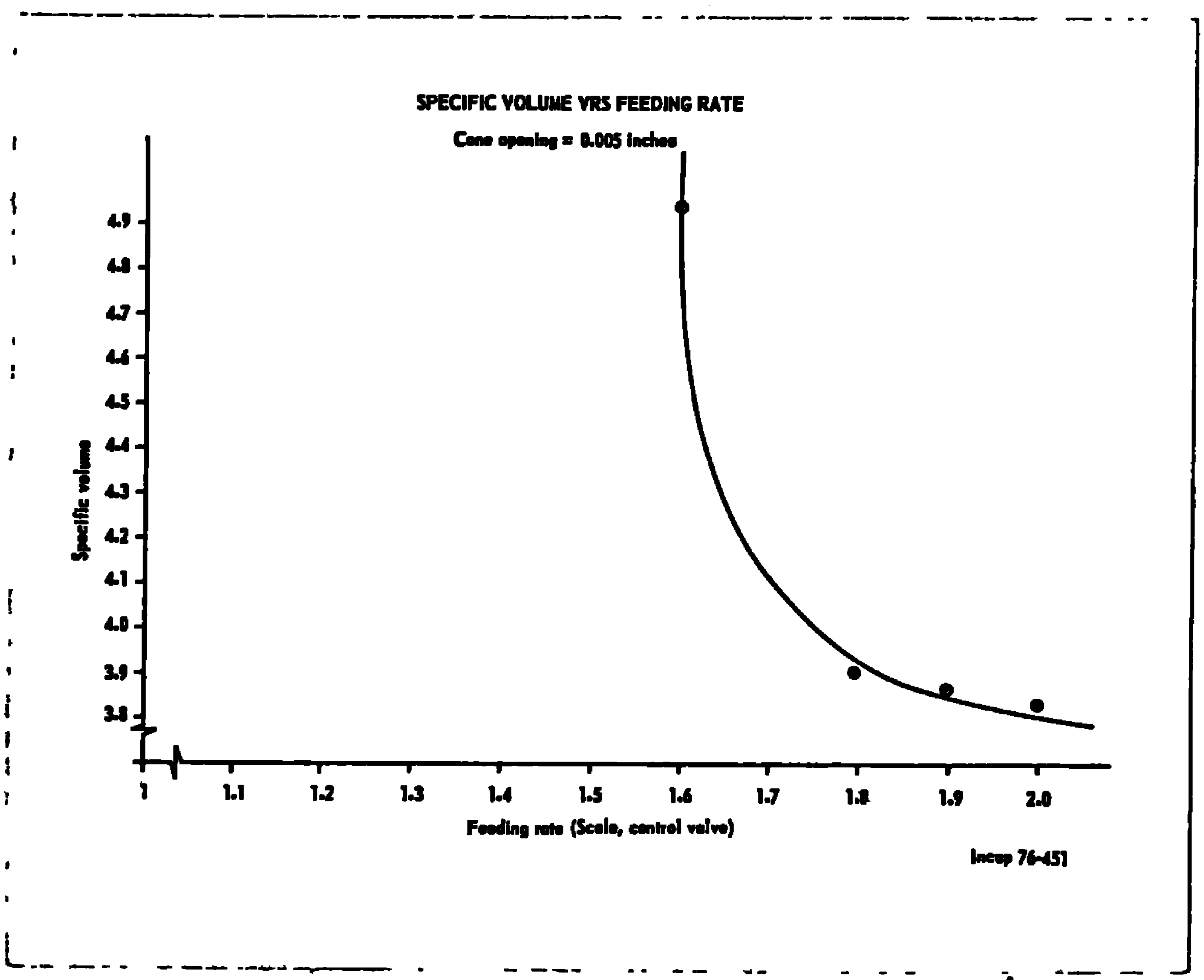

TEMPERATURE OF EXTRUSION VRS FEEDING RATE
Cone opening = 0.005 inches
Temperature, °F
330
325
320
315
310
305
300
1.6
1.7
1.8
1.9
2.0
Feeding rate (Scale, control valve)
Incap 76 452

FIGURE 1.



SPECIFIC VOLUME VRS FEEDING RATE
Cone opening = 0.005 inches
Specific volume
4.9
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4.0
3.9
3.8
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
Feeding rate (Scale, control valve)
Incap 76-451

FIGURE 2.

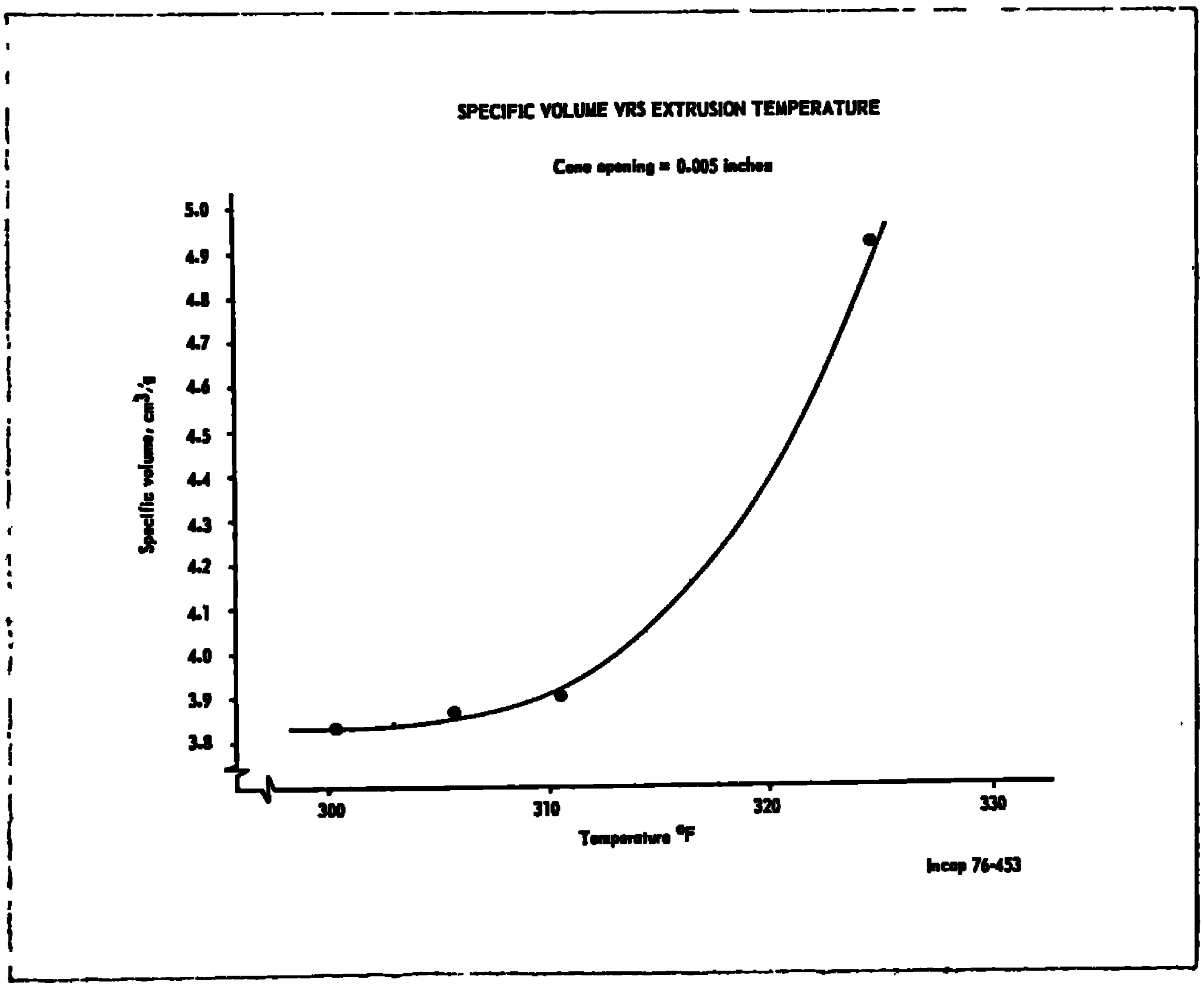

SPECIFIC VOLUME VRS EXTRUSION TEMPERATURE
Cone opening = 0.005 inches
5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4.0
3.9
3.8
Specific volume, cm³/g
300
310
320
330
Temperature °F
Incap 76-453

FIGURE 3.

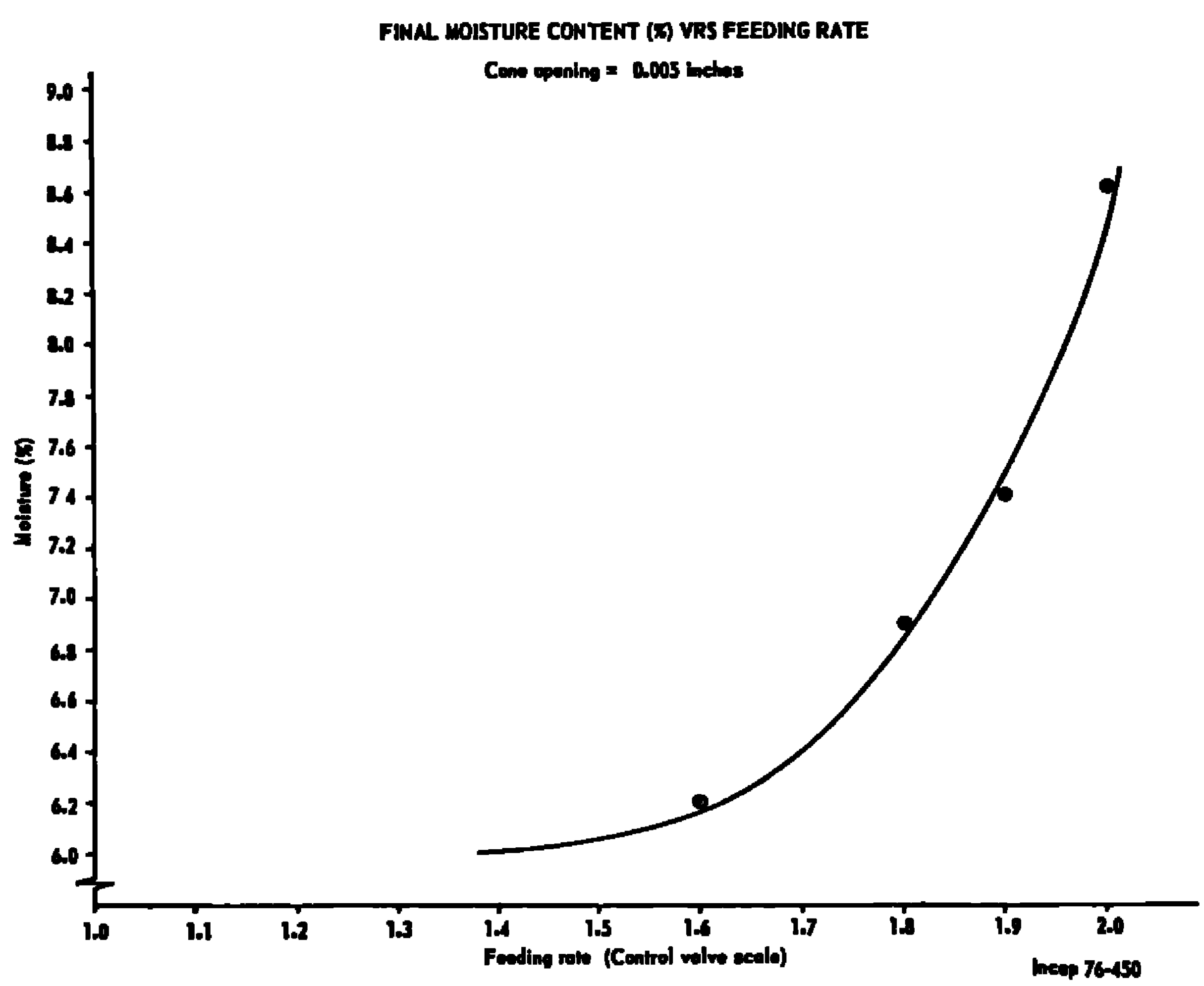

FINAL MOISTURE CONTENT (%) VRS FEEDING RATE
Cone opening = 0.005 inches
Moisture (%)
9.0
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
6.2
6.0
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
Feeding rate (Control valve scale)
Incap 76-450

FIGURE 4.

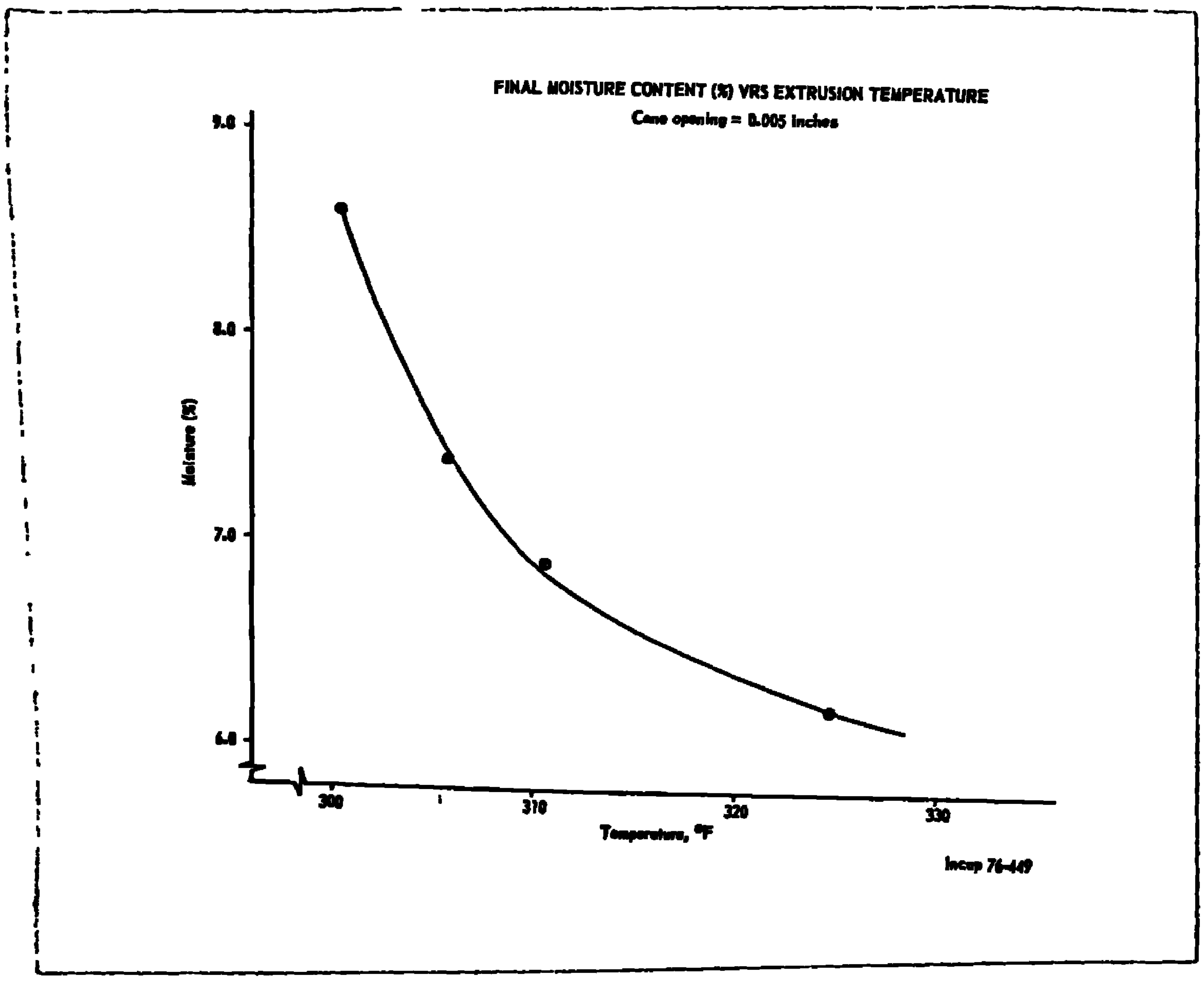

FINAL MOISTURE CONTENT (%) VRS EXTRUSION TEMPERATURE
Cone opening = 0.005 inches
9.0
8.0
7.0
6.0
Moisture (%)
300
310
320
330
Temperature, °F
Incap 76-449

FIGURE 5.

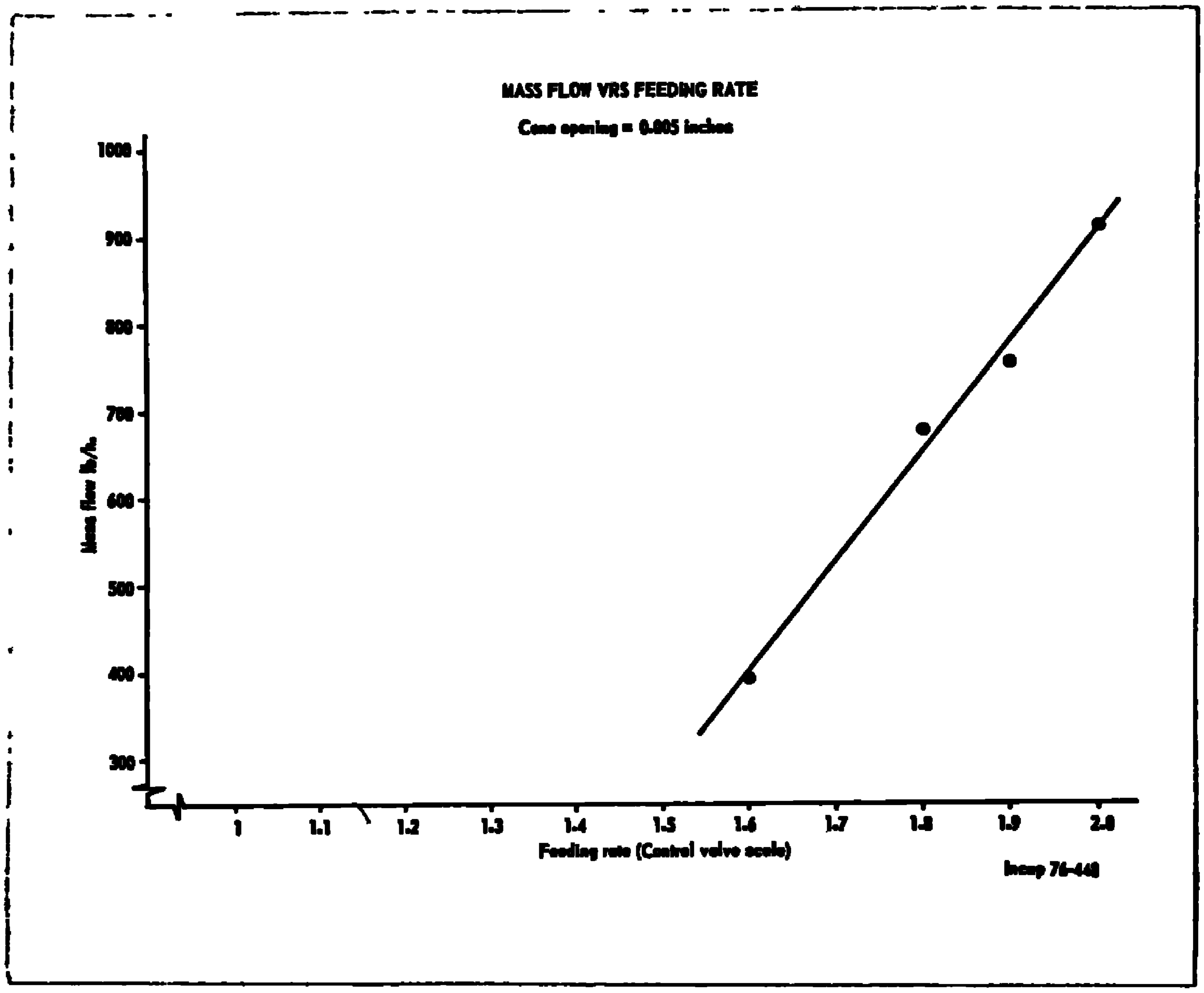
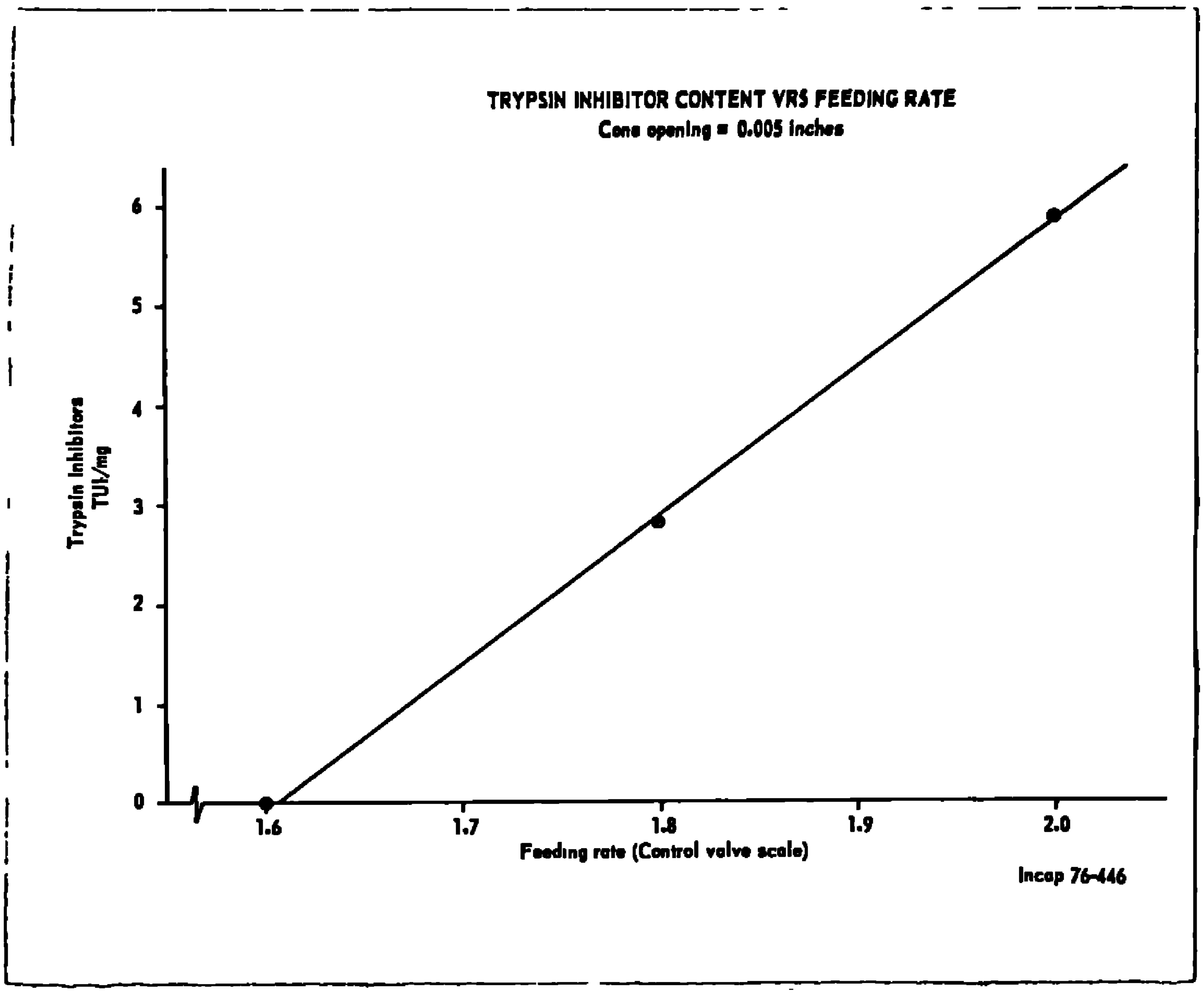

MASS FLOW VRS FEEDING RATE
Cone opening = 0.005 inches
1000
900
800
700
600
500
400
300
Mass flow lb/h.
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
Feeding rate (Control valve scale)
Incap 76-448

FIGURE 6.



TRYPSIN INHIBITOR CONTENT VRS FEEDING RATE
Cone opening = 0.005 inches
Trypsin inhibitors
TUI/mg
0
1
2
3
4
5
6
1.6
1.7
1.8
1.9
2.0
Feeding rate (Control valve scale)
Incap 76-446

FIGURE 7.

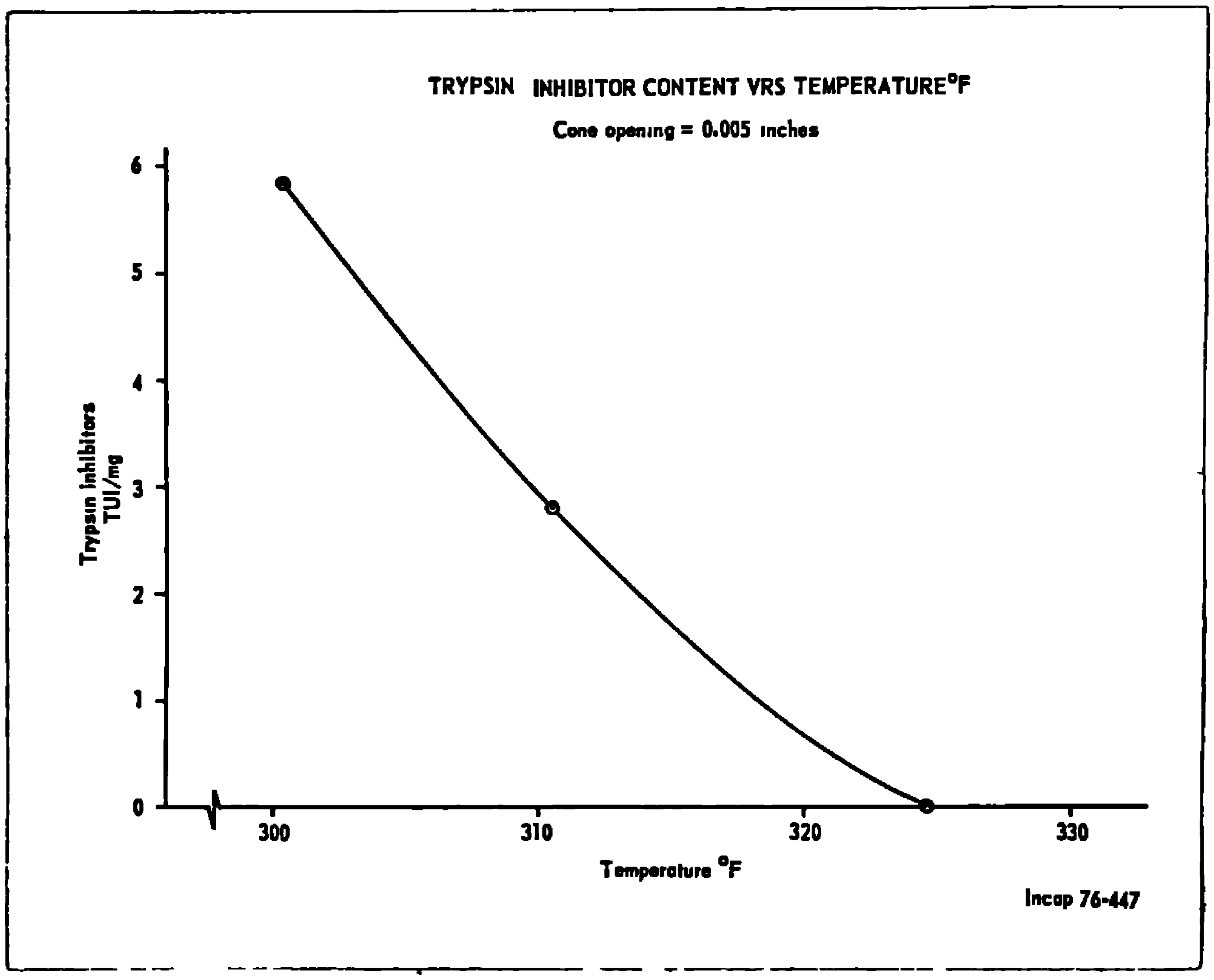

TRYPSIN INHIBITOR CONTENT VRS TEMPERATURE°F
Cone opening = 0.005 inches
Trypsin Inhibitors
TUI/mg
6
5
4
3
2
1
0
300
310
320
330
Temperature °F
Incap 76-447

FIGURE 8.

TABLE 1
EXTRUDING PROCESSING CONDITIONS OF A CORN/SOYBEANS MIXTURE (60/40)

Feeding rate	Temperature °F	Sp. Vol. cm/g	Mass flow lb/hr	Moisture %*	Cone opening inches	Trypsin inhibitors
2.0	300.43	3.838 ± 0.064	919.43	8.6	0.005	5.85
1.9	305.67	3.865 ± 0.078	752.67	7.4	0.005	–
1.8	310.50	3.901 ± 0.096	676.50	6.9	0.005	2.8
1.6	324.67	4.914 ± 0.043	391.33	6.2	0.005	0.0

* Initial moisture: 12.2%

V. CONTROL MECHANISM OF THE BRADY CROP COOKER CONE OPENING

In the Koehring 2160 Extruder/Cooker (Brady Crop Cooker) the variables regulating the processing conditions are the cone opening in the extruder screw, and the rotation velocity of the feeding screw which controls the rate of feeding. The rotation velocity can be controlled by a valve which comes with the equipment. The opening of the cone is regulated by a crank, a turn of which is equal to approximately 0.02 inches in the cone opening; there is no mechanism, however, to determine the opening at which one is working at a given moment. To solve this problem, an automatic system was devised whereby one can determine at how many crank turns the extruder is operating and know thereby what cone opening is being used at any time during the processing. The device is shown in the attached drawing.

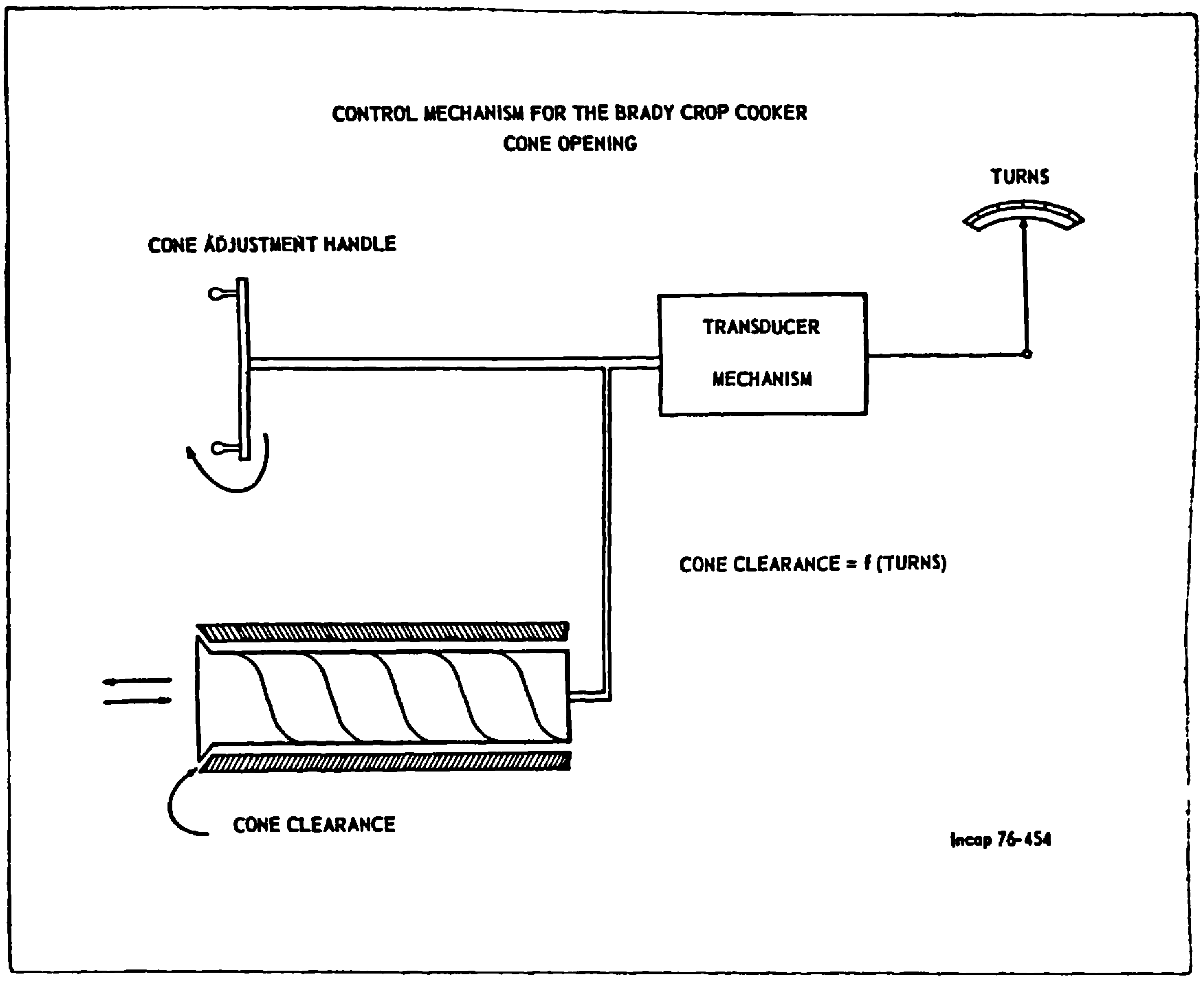

CONTROL MECHANISM FOR THE BRADY CROP COOKER
CONE OPENING
TURNS
CONE ADJUSTMENT HANDLE
TRANSDUCER
MECHANISM
CONE CLEARANCE = f (TURNS)
CONE CLEARANCE
Incap 76-454

FIGURE 1.

VI. EXTRUSION OF MIXTURES OF CORN/COWPEA AND CASSAVA/COWPEA FOR ANIMAL FEEDS. NUTRITIONAL QUALITY OF PIGS

In the previous report, results were shown which indicated the possibility of obtaining mixtures of root crops and legumes suitable for human consumption by extrusion processing. The data also demonstrated that the protein value of such mixtures was improved by the process as measured by biological assays with rats.

The main objective of the present study was to test the possibility of substituting a mixture of cowpea/corn (65/25) for a soybean/corn (25/65) mixture, and also of replacing a mixture of soybean/cassava (36/54) by a mixture of cowpea/cassava (72/18). The cowpea/corn in both cases was tested raw and extruded by using the Brady Crop Cooker.

Processing conditions in the Brady Crop Cooker

All ingredients were previously ground to pass through a 20 mesh.

Temperature of processing: 290 – 300 °F

RPM: 600

Output rate: 860 lbs/hour

After processing, the cooked cowpea/corn mixtures were ground to pass through a 20 mesh.

Biological tests

Feeding trials were carried out in baby pigs of the Landrace strain, and data on feed intake and weight gain were recorded weekly during an eight-week period. Based on the results, feed efficiency was calculated. It was found that the animals fed the soybean/corn diet had an average weight gain of 33.1 kg, while pigs fed the extruded cowpea/corn diet gained an average of 20.5 kg. The animals fed the raw cowpea/corn diet resulted on an average weight gain of only 11.0 kg. showing the beneficial effect of the extrusion process on the nutritive value of the cowpea/corn diet. On the other hand, it was also found that replacement of the soybean/cassava diet by the extruded cowpea/cassava mixture gave an average weight gain of 22.8 kg as compared with 28.3 kg for the animals fed the soybean/cassava diet. The results obtained for all the feed combinations are summarized in Figure 1. Additional data on feed intake and feed efficiency are shown in Table 1. In the case of the cowpea/corn mixture extrusion processing also improved feed intake, suggesting the positive effect of the mixture's palatability. The cowpea/cassava diet processed by the Brady Crop Cooker gave similar feed conversion value as compared to the soybean/cassava mixture.

Studies are now under way to determine the reasons for the lower performance of the animals fed the cowpea/corn and cowpea/cassava diets as compared with those fed the soybean/corn and soybean/cassava mixtures. Aside from the results obtained, it is important to point out that the cowpea (Vigna sinensis), as well as the cassava, are excellent raw materials for animal feeds and are available in Central America.

TABLE 1

EFFECT OF THE EXTRUSION PROCESS ON FEED INTAKE, WEIGHT GAIN, AND FEED EFFICIENCY OF BABY PIGS FED MIXTURES OR COWPEA/CORN AND COWPEA/CASSAVA*

Mixture	Extrusion	Feed intake kg	Weight gain, kg/day	Feed efficiency
Soybean/corn, 25/65	No	90.5	0.59	2.7
Cowpea/corn, 65/25	No	36.0	0.19	3.3
Cowpea/corn, 65/25	Yes	47.0	0.36	2.4
Soybean/cassava, 36/54	No	75.0	0.50	2.6
Cowpea/cassava, 72/18	Yes	59.0	0.40	2.6

* Each experimental group consisted of 8 animals (4 males and 4 females)

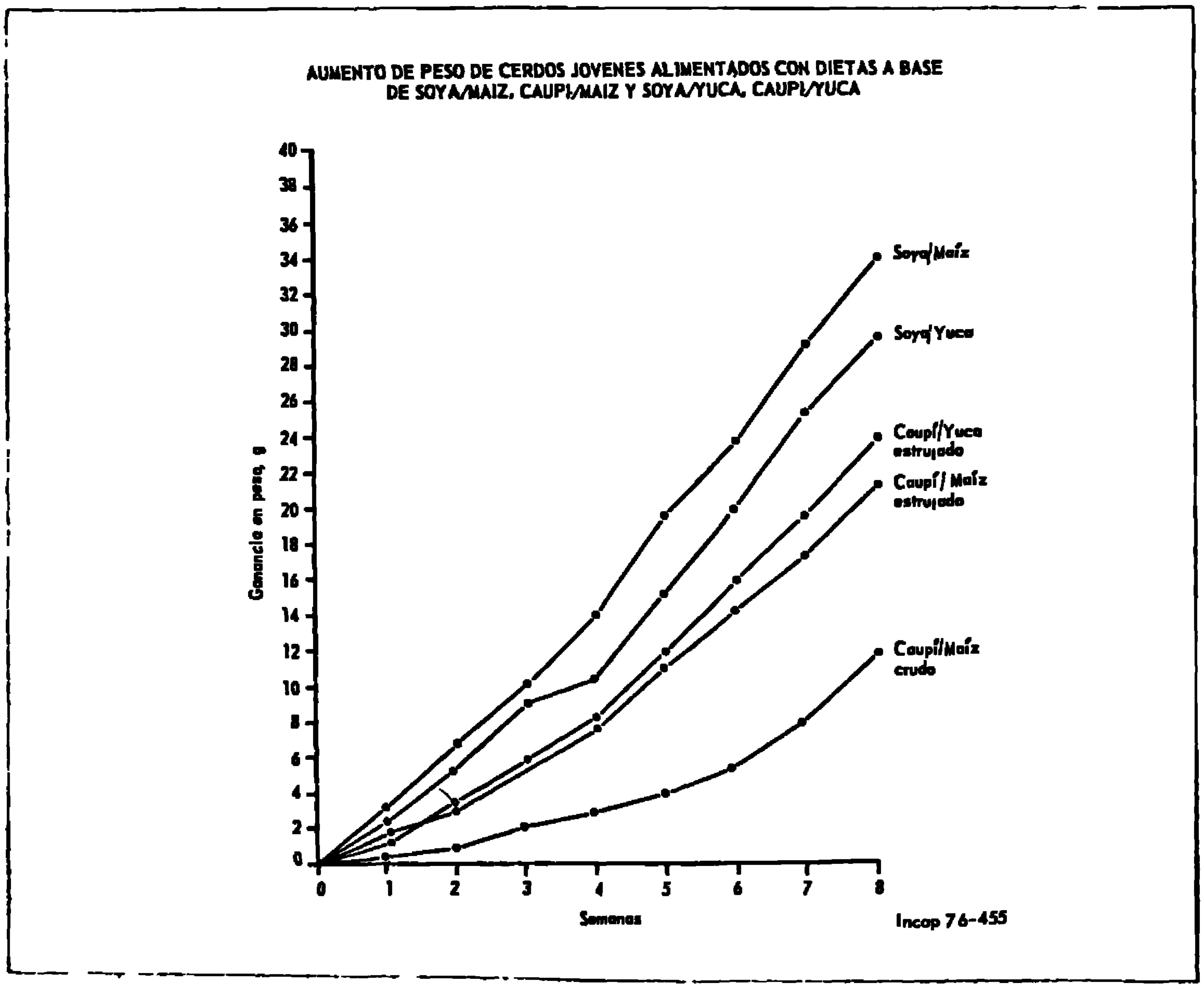

AUMENTO DE PESO DE CERDOS JOVENES ALIMENTADOS CON DIETAS A BASE DE SOYA/MAIZ, CAUPI/MAIZ Y SOYA/YUCA, CAUPI/YUCA
Ganancia en peso, g
Semanas
Soya/Maíz
Soya/Yuca
Caupí/Yuca estrujado
Caupí/ Maíz estrujado
Caupí/Maíz crudo
Incap 76-455

FIGURE 1.