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Hydrocarbon grown yeast as the protein source of diet for dairy beef production

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(Figs. 1-2, Text-figs. 1-2, Tables 1-13)

Hydrocarbon grown yeast is the name given microorganisms fed on n-paraffin in petroleum instead of carbohydrates such as; molasses, starch and glucose as its carbon sources. And microorganisms are generally protein rich, they are called hydrocarbon grown yeast[1].

Although there are increasing demands all over the world for formula feeds in recent years, the unstable supply of soybean meal and fish meal becomes an acute important problems.

There are certainly still many problems that remain unsolved in the hydrocarbon grown yeast production. And so the safety of products from animals fed with hydrocarbon grown yeast has not yet been aknowledged by national consensus. Yet it is likely that in the near future the yeast will have to yield its place as one of the protein source to formula feeds.

For several years Japanese researchers have studied the nutritive values of hydrocarbon grown yeast[2]. During 1969-1970 the following papers were reported; for broiler NISHIKAWA *et al.* (1969)[3], FUJITA *et al.* (1969)[4], SHIGENO and TANAKA (1969)[5]; for layer NISHIKAWA *et al.* (1969)[6], SEO *et al.* (1970)[7], TADA *et al.* (1970)[8]; for swine NISHIKAWA *et al.* (1969)[9], *et cetra.*

From the results of these studies the yeast stands as an efficient protein source which may become a substitution for the 50-100 percentages of fish meal and soybean meal. The nutritional contents of hydrocarbon grown yeast are shown in Table 1 and the amino acids and vitamine contents in Table 2. Rich contents of protein and lysin, but comparatively poor contents of methionin and cystin are noticed. The methionin and cystin contents are a little lower than in fish meal, but of the same level as in vegetable protein such as in soybean meal. Therefore, researchers reported that it would be more effective for broiler, layer and swine

Table 1. General composition of hydrocarbon grown yeast (%).

Moisture	4.5	
Protein	60.1	(Digestion rates of protein: Chicken 84.8-88.0, Pig 88.3-89.3)
Fat	3.2	
Fiber	3.5	
Ash	6.2	
N.F.E.	22.5	

Table 2. Amino acids composition and vitamins of hydrocarbon grown yeast.

Amino acids composition (%)		Vitamins	
Aspartic acid	5.65	Vitamin B_1	0.85 mg%
Threonine	3.06	Vitamin B_2	6.98 mg%
Serine	2.83	Vitamin B_6	0.57 mg%
Glutamic acid	8.33	Vitamin B_{12}	3.01 γ%
Proline	2.62	Niacin	45.00 mg%
Alanine	3.66	Biotin	11.90 γ%
Cystine	1.06	Cholin	0.74 %
Valine	3.27	Folic acid	0.10 mg%
Methionine	0.73		
Isoleucine	3.28		
Leucine	3.75		
Tyrosine	1.98		
Phenylalanine	2.62		
Tryptophan	0.73		
Lysine	4.52		
Histidine	1.33		
Arginine	2.72		

productions to add some amounts of methionin and cystin to hydrocarbon grown yeast.

As mentioned above, reports on cattle fed with hydrocarbon grown yeast are still few, yet formula feed for cattle is increasing more and more in Japan. The reason is probably the increasing tendency of diet amounts fed to fattening steers and dairy beefs. In these diets fish meal and soybean meal have been used in an average of 10 to 20 percent of the diet as protein sources. Therefore if they could be substituted by synthetic protein such as hydrocarbon grown yeast, a remarkable rich new source of protein diet could be obtained.

In dairy beef production milk replacers are used for baby calves as a substitute for cow milk during the nursig period, and calf staters are used for baby calves from pre-weaning to the age of three months. Another formula feed is used for steer during pre-fattening and fattening periods.

In the present investigation the authors have performed a series of raising experiments of dairy beef production to determine the value of hydrocarbon grown yeast as a protein source for one and a half year from September, 1971 until February, 1973.

Hydrocarbon grown yeasts were presented by Kanegafuchi Chemical Industrial Co. Ltd., they had been produced by culturing several strains on n-paraffin.

MATERIAL AND METHODS

1. Animals

Six calves were selected and brought to the University Farm in September, 1971 they were born on neighbourhood farms and had been nursed with their mothers milk for about one weeks. The calves are described in detail in the Table 3.

Table 3. Holstein calves investigated.

Group	No.	Sex	Date of birth	At introduction	
				Age	Body weight
Control	1	♂	Sept. 14	9 days	43 kg
	3	♂	Sept. 13	15	50
	5	♂	Sept. 24	7	37
Yeast	2	♂	Sept. 21	7	46
	4	♂	Sept. 26	9	50
	6	♂	Sept. 27	9	38

2. Feeding program and management

The calves were devided into two groups; three into a yeast group and another three into a control group, they all had been fed under the feeding program described in Table 4.

The compositions of the three diets used in the present trial are shown in Tables 5-7.

The diets offered to the yeast group were differed only in the compositions of fish soluble, fish meal, soybean meal and linseed meal from the control diet. That is, fish soluble and soybean meal in milk replacer, fish meal and soybean meal in calf stater, and cottonseed meal and soybean meal in fattening diet were replaced with hydrocarbon grown yeast.

The calves were dehorned at about three weeks age and were castrated at about six months old.

The calves fed under milk replacer and calf stater had been reared first in individual stall pen, then they were introduced into stanchion stall barn, in which Italian rye-grass hay had been given once a day in the afternoon and formula feed had been given in the morning.

Fresh water had been supplied *ad libitum* by water-cup.

Table 4. Feeding program in present trial.

Age	Milk replacer	Calf stater	Diet for raising and fattening	Hay
1 wk.				
2	0.5 kg	0.1 kg		
3	0.5	0.1		
4	0.5	0.2		
5	0.5	0.4		0.10 kg
2 months		2		0.10
3		3		0.35
4			4.0 kg	0.70
5			4.5	0.85
6			5.0	0.85
7, 8			5.0	1.0
9, 10			6.0	1.75
11, 12			7.0	3.0
13, 14			8.0	3.0
15, 16			9.0	3.0

Remarks : 1) Calves were dehorned at 3 weeks of age.
2) Calves were castrated during 5–6 months of age.

Table 5. The composition of milk replacer (%).

Ingredients \ Group	Control	Experimental
Dried skim milk	65.5	65.5
Dried whey	10	10
Tallow	14	14
Soybean meal (CP 50%)	5	—
Fish soluble	5	—
Yeast	—	10
Additives	0.5	0.5
Total	100	100
CP	27.3	28.8
DCP	24.3	25.7
TDN	93.6	94.3

Table 6. The composition of calf stater (%).

Ingredients \ Group	Control	Experimental
Corn	36	35
Fish meal	5	—
Soybean meal	20	15
Linseed meal	10	10
Yeast	—	10
Beet pulp	5	5
Alfalfa meal	10	10
Molasses	6	6
Fat	5	5
$CaCO_3$	1.0	2.0
$Ca_3(PO_4)_2$	1.0	0.9
NaCl	0.5	0.55
Additives	0.5	0.5
Total	100	100
CP	21.0	21.2
DCP	18.7	18.7
TDN	75.1	75.1

Table 7. The composition of diet for fattening (%).

Ingredients \ Group	Control	Experimental
Corn	10	18
Milo	20.9	20.9
Barley	20	20
Cottonseed meal	10	—
Soybean meal	5	—
Yeast	—	10
Alfalfa meal	24.9	24.3
Molasses	5	5
Fat	3	0.6
NaCl	0.3	0.3
$CaCO_3$	0.5	0.5
$Ca_3(PO_4)_2$	0.3	0.3
Additives	0.1	0.1
Total	100	100
CP	14.9	15.2
DCP	13.1	13.4
TDN	73.2	72.1

3. Measurement and carcass investigation

Growth in live weight and development in linear measurements were examined at one or two weeks intervals.

Cattle investigated were slaughtered on January 17th, 1973. At that time the internal organs of the individuals were weighed and inspected for possible abnormalities, also the carcass quality of individuals were graded by a well known specialist Mr. K. Okui. The check-points for grading were the following; eye-muscle area, fat covering, meat colour and brightness, texture and firmness, carcass weight, dressing percentage of carcass, marbling score *et cetra*.

4. Urine inspection and haematoscopy

On January 16th, 1973, the day before slaughter urine inspection and haematoscopy were conducted on each cattle by the laboratory staffs of the Polyresearch Center Co. Ltd.

RESULTS

1. The growth of the nursing bull calf

The changes in live weights are showed in Table 8 and are figured on Text-figure 1.

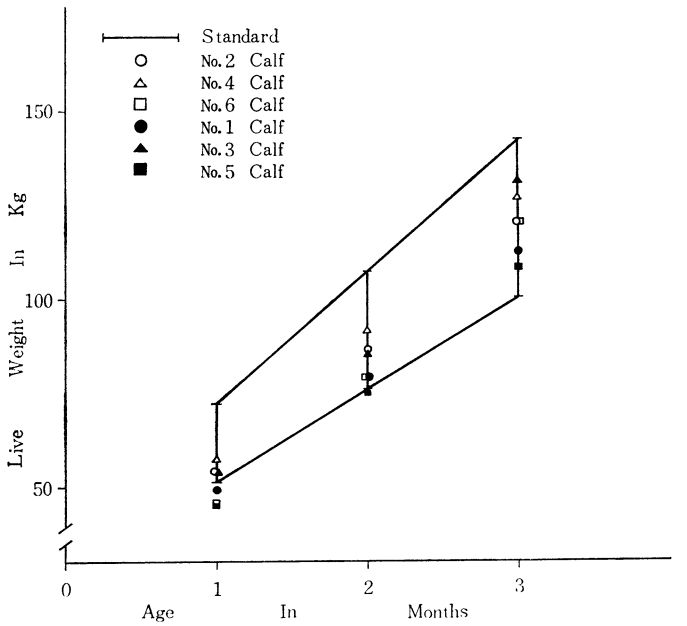
Table 8. The growth of investigated animal.

		Control group				Yeast group			
		No. 1	No. 3	No. 5	Av.	No. 2	No. 4	No. 6	Av.
Live weights	Beginning of investigation	kg 43	kg 50	kg 37	kg —	kg 46	kg 50	kg 38	kg —
	5 weeks old	52	60	50	54	56	59	51	55
	3 months old	112	131	108	117	120	127	120	122
Daily gain		0.83	1.05	0.84	0.90	0.87	0.93	0.99	0.93
Live weights	3 months old	112	131	108	117	120	127	120	120*
	6 months old	218	248	223	230	229	216	226	228*
	9 months old	314	337	326	326	329	314	336	333*
	12 months old	423	439	415	426	409	394	449	429*
	15 months old	511	549	510	525	487	—	541	514*
	Finish	541	571	517	543	501	—	553	527*
(Ages, day)		(490)	(491)	(480)		(482)	—	(477)	
Weight gain**		429	440	409	426	381		433	407*
Daily gain**		1.08	1.10	1.05	1.08	0.98		1.14	1.05*

Remarks : 1) * Average of No. 2 and No. 6 excluding No. 4.

2) ** Gain during from the 3 months old to the finish.

3) The differences of average weight and daily gain from beginning of investigation to 3 months of age are not significant.



Text-fig. 1. Growths in live weight of investigated calf from beginning to 3 months of age. Standard is the standard growth values of Holstein bull calf, reported by H. C. A. J. (1962)

Table 9. Feed intake of investigated animal (unit: kg).

	Control group				Yeast group			
	No. 1	No. 3	No. 5	Av.	No. 2	No. 4	No. 6	Av.
Milk replacer	14	14	14	14	14	14	14	14
Calf stater	140.5	141.5	157.0	146.0	152.0	144.0	140.0	145.0
DCP intake*	29.67	29.86	32.76	30.76	32.02	30.53	29.78	30.78
DCP efficiency**	2.32	2.71	2.17	2.40	2.31	2.52	2.75	2.52
Formula feeds intake	2346	2326	2342	2338	2339		2339	2339
DCP intake from formula feeds***	307.3	304.7	306.8	306.2	313.4		313.4	313.4
DCP efficiency***	13.96	14.44	13.33	14.14	12.16		13.82	12.99

Remarks : 1) * DCP intake from beginning to the 3 months old is calculated from DCP percentage of feeds.

2) ** DCP efficiency from beginning to the 3 months old is calculated from weight gain kg/DCP intake.

3) *** DCP intake and DCP efficiency were calculated from formula feeds during the 3 months old to the finish.

4) Hay consumed by animals were about 735 kg per head respectively.

The average daily gains during nursing periods which were calculated from growth in live weights at age of three months are not significantly different.

As described in Table 9 there are no significant differences between the two groups in feeds amounts intake. Although the amounts of calf stater intaked were quite similar, DCP intakes were a little larger in the yeast group than the control group. This might be due probably to the rich protein content of yeast. DCP efficiency is, therefore, a little advantagious in the control group.

If we use the normal growth value of the bull calf which were reported by the Holstein Cattle Association of Japan in 1962[10] and compare it to the present data, all calves showed a little under-growth, as figured on Text-figure 1. But there was no evidence of any significant effects of hydrocarbon grown yeast.

2. The growths and developments of cattle investigated

The calves had been fed from 3 months old to finishing and then were slaughtered about 483 days of age.

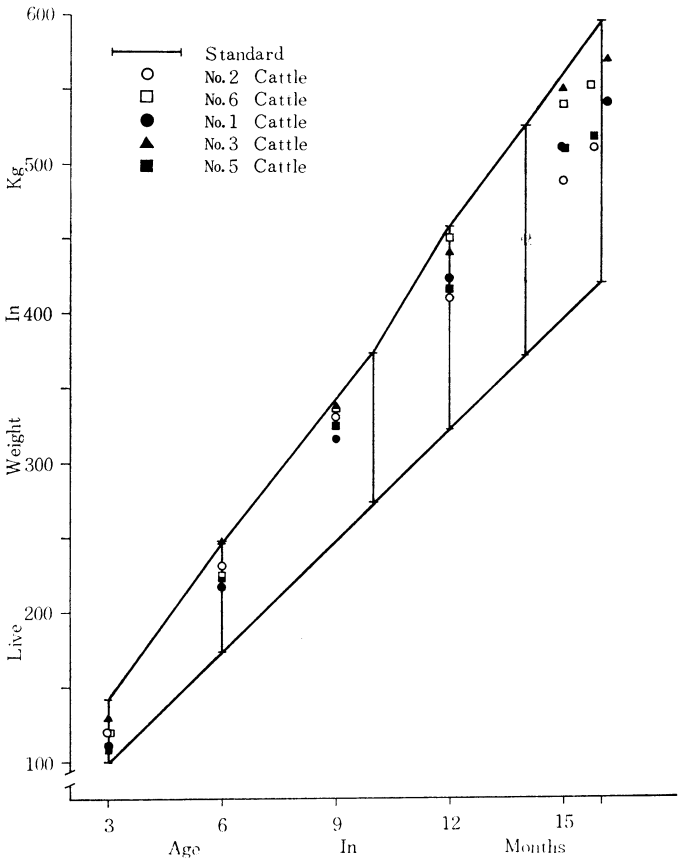
As the data indicated in Table 8, 10 and Text-figure 2, their growth curves are similar and it can be traced along the upper line of the standard as mentioned above. Average daily gains of two groups are quite of similar value, i.e. 1.1 kg respectively.

The amounts of formula feeds intaked by the cattle were average 2338 kg (control group) and 2339 kg (yeast group), respectively. Therefore, there are no tendencies of differences in case of daily gains, feed intakes and feed efficiencies between two groups.

Cattle No. 4 died at December 4th, 1972. The death was diagnosed by office vetrinarian as a result of acute bloat.

Table 10. Development in linear measurements of cattle investigated (cm).

Items and ages		Cattle investigated				
		Control group			Yeast group	
		No. 1	No. 3	No. 5	No. 2	No. 6
Withers height	4 months	101	108	100	101	101
	Finish	133	137	135	132	137
Body length	4 months	118	123	114	115	117
	Finish	150	165	156	157	162
Cannon circumference	4 months	15	16	15	15	16
	Finish	19	19	19	19	20



Text-fig. 2. Growths in live weight of investigated animal from 3 months of age to the day before slaughtering. Standard is the standard growth values of Holstein bull reported by H. C. A. J. (1962)

Carcass inspection was conducted by office veterinarian at the time of slaughtering, and it was recognized that there was no evidence whatsoever of any remarkable abnormality in the internal organs of the cattle.

3. Carcass quality and carcass grade

The carcass weights and dressing percentages are given in Table 11. The carcass qualities and carcass grades are given in Table 12. The average carcass weight was 303 kg for the control group and 301 kg for the yeast group, it indicates that there is no different tendecy for the two groups.

From the results of the carcass grade investigations the cattle in the yeast group get a slightly higher rank than of cattle in the control group.

4. Urine inspection and haematoscopy

The results of urine inspections and haematoscopies conducted by the laboratory staffs of the Polyresearch Center Co. Ltd. are summarized in Table 13.

There is no evidence of abnormalities in each cattle group.

Table 11. Carcass weight (kg) and dressing percentage (%).

Items	Control group				Yeast group		
	No. 1	No. 3	No .5	Av.	No. 2	No. 6	Av.
Carcass weights*							
left	149	159	144	151	143	155	149
right	150	161	146	152	146	157	152
total	299	320	290	303	289	312	301
Dressing percentage	57.8	57.5	57.8	57.7	59.5	58.0	58.8

Remark : * Warm carcass weights.

Table 12. Carcass evaultion of cattle investigated.

	Control group			Yeast group	
	No. 1	No. 3	No. 5	No. 2	No. 6
Proportion	Middle	High	Middle	Middle	High
Fleshness	High	High	Middle	Middle	High
Fat covering	High	High	Middle	Middle	High
Dressed condition	Highest	Highest	Highest	Highest	Highest
Marbling	0.5	0.3	0.5	0.5	1.0
Meat colour and brightness	High	High	High	High	High
Texture and firmness	Middle	High	High	High	High
Fat colour and gloss	High	High	High	High	High
Fat quality	Middle	High	Middle	Middle	High
Carcass grade	Medium	Medium	Medium	Good	Good

Remarks : 1) Carcass grade Good is corresponding to Good in USA system of feeder steers, and Medium is to Medium.

2) Carcass evaultion was conducted by Mr. K. Okui.

Table 13. Results of urine inspection and haematoscopy of cattle investigated at the day before slaughtering.

Items	Cattle investigated				
	No. 1	No. 3	No. 5	No. 2	No. 6
Urine inspection					
pH	8.5	8.0	8.0	8.0	8.0
Protein (mg/dℓ)	0	0	0	0	0
Sugar (g/dℓ)	0	0	0	0	0
Ketone	—	—	—	—	—
Biochemical inspection					
GOT (KU)	51	59	44	51	54
GPT (KU)	19	23	18	19	22
Biliru (mg/dℓ)	0.2	0.2	0.2	0.2	0.2
TP (g/dℓ)	6.8	6.9	6.5	7.8	6.9
T.T.T. (U)	0.3	0.3	0.3	0.6	0.4
Z.T.T. (U)	1.4	1.8	1.4	2.8	1.4
T. chol. (mg/dℓ)	157	93	113	111	90
Blood sugar (mg/dℓ)	180	83	82	85	87
U—N (mg/dℓ)	12.5	13	14.5	13.5	13.5
Haematoscopy					
RBC	678	748	643	871	664
Hb	11.6	12.1	10.9	13.5	12.1
Ht	31.5	31.5	29.0	37.5	33.0
WBC	10,950	10,100	11,950	10,600	10,050
Bas	0	0	0	0	0
Eos	3.0	6.0	5.0	8.0	19.0
Mbl	0	0	0	0	0
Prot. N	0	0	0	0	0
Ly	77.0	81.0	80.0	53.0	69.0
Mo	3.0	7.0	4.0	8.0	3.0
Plasma	0	0	0	0	0

Remark : Investigations were conducted by the laboratory staffs of the Polyresearch Center Co. Ltd.

DISCUSSION

From the results of this research it is allowed to conclude that hydrocabon grown yeast is able to be used as a protein source of diets for dairy beef production. The growth curves of each one of the calves during nursing period were not completely in accordance with the normal curve for bull calves which was reported by the Holstein Cattle Association of Japan. However there were no significant differences between the yeast group and the control group.

Milk replacer is mainly composited with skim milk powder. Therefore, soybean meal, fish soluble and hydrocarbon grown yeast will never play an im-

portant role as protein source for nursing baby calves; but in calf stater these foods may have important effects on the growth of calves. In either cases, it may be assumed that hydrocarbon grown yeast is apt to be used as a protein source of diets for nursing calves offering a value similar to fish meal and soybean meal.

A slightly lower DCP efficiency during the nursing period would be contributed to a higher protein content of hydrocarbon grown yeast. This explanation however can not yet be proven in a satisfying way.

After 3 months of age the growth curves of the cattle investigated were along the upper line of the standard curve through their lives, and their live weights and daily gains were also in accordance with the data suggested by FUKUSHIMA (1969)[11].

KAWAI *et al.*[12] have asserted that if the growth curve of cattle was along the upper line of the standard curve of bull reported by the Holstein Cattle Association of Japan (1962), the growth would be considered as normal. Therefore, these results suggest that the growth of the investigated cattle was normal to dairy beef production, where hydrocarbon grown yeast was a main protein source of the diet during the raising and fattening periods of the dairy beef.

As mentioned in the introduction of this report, hydrocarbon grown yeast has a slightly lower content of methionin and cystin than fish meal. The authors supposed before the planning of the experimental design that lower content of methionin and cystin would not effect the growth of cattle, because the microorganismic rumen function would cover up the effect cf protein quality to some extent. The average daily gains of 1.1 kg in the two groups suggest that the addition of methionin and cystin is not required for a diet on hydrocarbon grown yeast after 3 months age of the cattle.

The problems of milk replacer and calf stater however have to be investigated further in the future.

Since both daily gain and amount of intaken formula feed were quite equal during the raising and fattening periods, there was no difference in feed conversions between two groups.

Cattle investigated had been in good health throughout the experiment and the authors could not find any abnormality from urine inspection, haematoscopy and inspection of internal organs. Stomach, liver, spleen, intestines, heart and lungs were mainly inspected, but nowhere noticeable symptoms of any metabolic disturbances such as liver abcesses, acidocis, rumen parakeratocis, scours, and urinary calculi[13]. Although No. 4 cattle which had been offered yeast died at 14 months

of age, post-mortem examination of this cattle revealed obious cause of death from acute bloat and not from the special material of formula feed.

In carcass characteristics and carcass grades hydrocarbon grown yeast group were superior, but it is difficult to consider that the difference in carcass characteristics were derived from the different protein source.

SUMMARY

1. Six calves were selected and nursed with milk replacer and calf stater from 7–15 days of age to 3 months of age. Three calves were given formula feeds which contained hydrocarbon grown yeast as a substitution for fish soluble, fish meal and soybean meal; the others were given control feeds.

2. After 3 months of age the calves had been raised in stanchion stalls and another formula feed for raising and fattening had been given, in which one for control and another diet contained hydrocarbon brown yeast for yeast group.

3. Cattle were slaughtered on January 17th, 1973. Average ages were about 483 days old.

4. The results are as follow:

1) There is no any different tendency of growth between the two groups.

2) Available evidence showed that hydrocarbon grown yeast may be substituted for fish meal and soybean meal. For example, average daily gain and feed efficiency were quite similar from 3 months of age to the finishing stage.

3) Carcass characteristics and carcass grades in cattle of the yeast group were a little higher than those of the control group. But it is most probably not significant.

4) The cattle investigated had been in good health throughout the experiment. While No. 4 cattle which had been fed on hydrocarbon grown yeast died at 14 months of age. The cause of death was diagnosed by the office veterinarian as acute bloat, without any connection to the yeast.

The authors wish to thank the Kanegafuchi Industrial Co. Ltd. for present them the hydrocarbon grown yeast and other formula feeds. Thanks are also due to the members of University Farm for assistance to carrying out present trial.

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炭化水素資化酵母の乳用雄子牛肥育における飼料価値

三村　耕・吉本　伝・三谷克之輔

炭化水素資化酵母（以下酵母と称する），いわゆる石油蛋白の蛋白質飼料源としての重要性は，その生産物の食品としての安全性とは別に，なお将来にわたり研究を要する課題と思われる．

これについての数多くの報告にもかかわらず，牛については公表されたものがほとんどなく，一方濃厚飼料多給方式の乳用雄子牛肥育は，近い将来わが国の牛肉生産の主力となるものと思われるので，鐘渕化学工業ＫＫ開発本部提供の酵母を用い，次の実験を行った．

7～15日令のホルスタイン種雄子牛6頭を附属農場に導入し，2区に区分し，試験区の3頭には，代用乳・人工乳期および育成・肥育期にわたり，魚粕・大豆粕などを酵母で完全に代替した飼料を給与した．

平均483日令でと殺・解体試験を行ったが，試験の結果は次の通りである．

1）3か月令までの発育には，両区に有意の差がなかった．飼料消費量にも差がなかった．したがって，代用乳・人工乳に酵母を添加する場合も，メチオニンなどの添加を必要としないようである．

2）6か月令で去勢し，約16月令まで肥育したが，その発育はホル協（'62）の雄牛標準発育値の上限に近かった．濃厚飼料消費量にも差が全くなかった．

3）と体の肉質検査・格付の結果は，酵母区がよい傾向であったが，有意とは考えられない．

4）供試牛は全期間ほぼ健康で推移し，酵母給与による栄養障害発生の徴候は，と殺時の内臓検査，と殺前日の尿・血液検査の結果からは認められなかった．ただし No. 4 牛は途中へい死したが，急性鼓脹症によるものと診断された．

5）以上の結果は，酵母が乳用雄子牛用飼料中の魚粕などに十分代替できることを示すものと思われるが，将来さらに検討するつもりである．

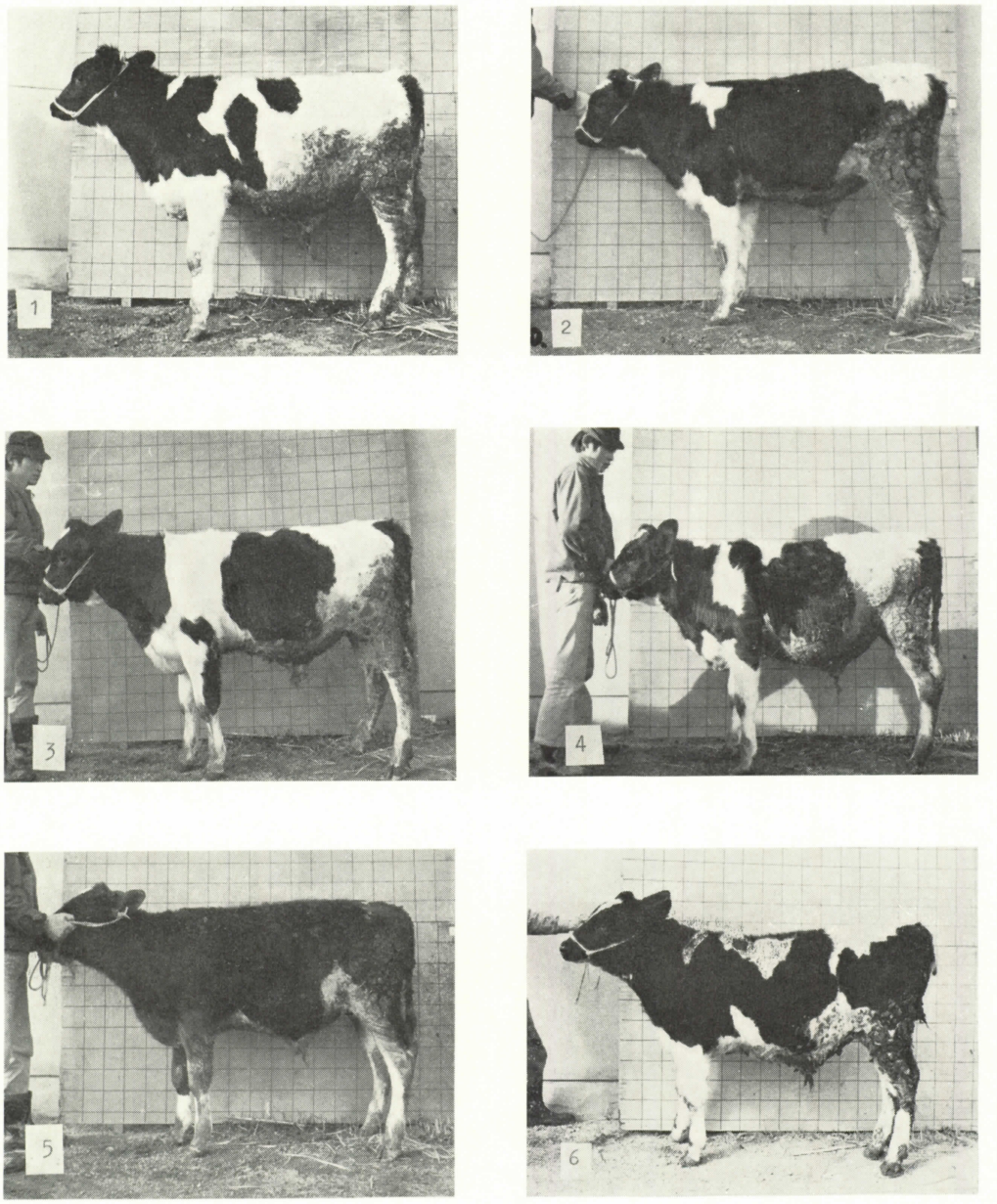

Fig. 1. Investigated calf at 3 months of age.

1 : No. 1, 2 : No. 2, 3 : No. 3, 4 : No. 4, 5 : No. 5, 6 : No. 6

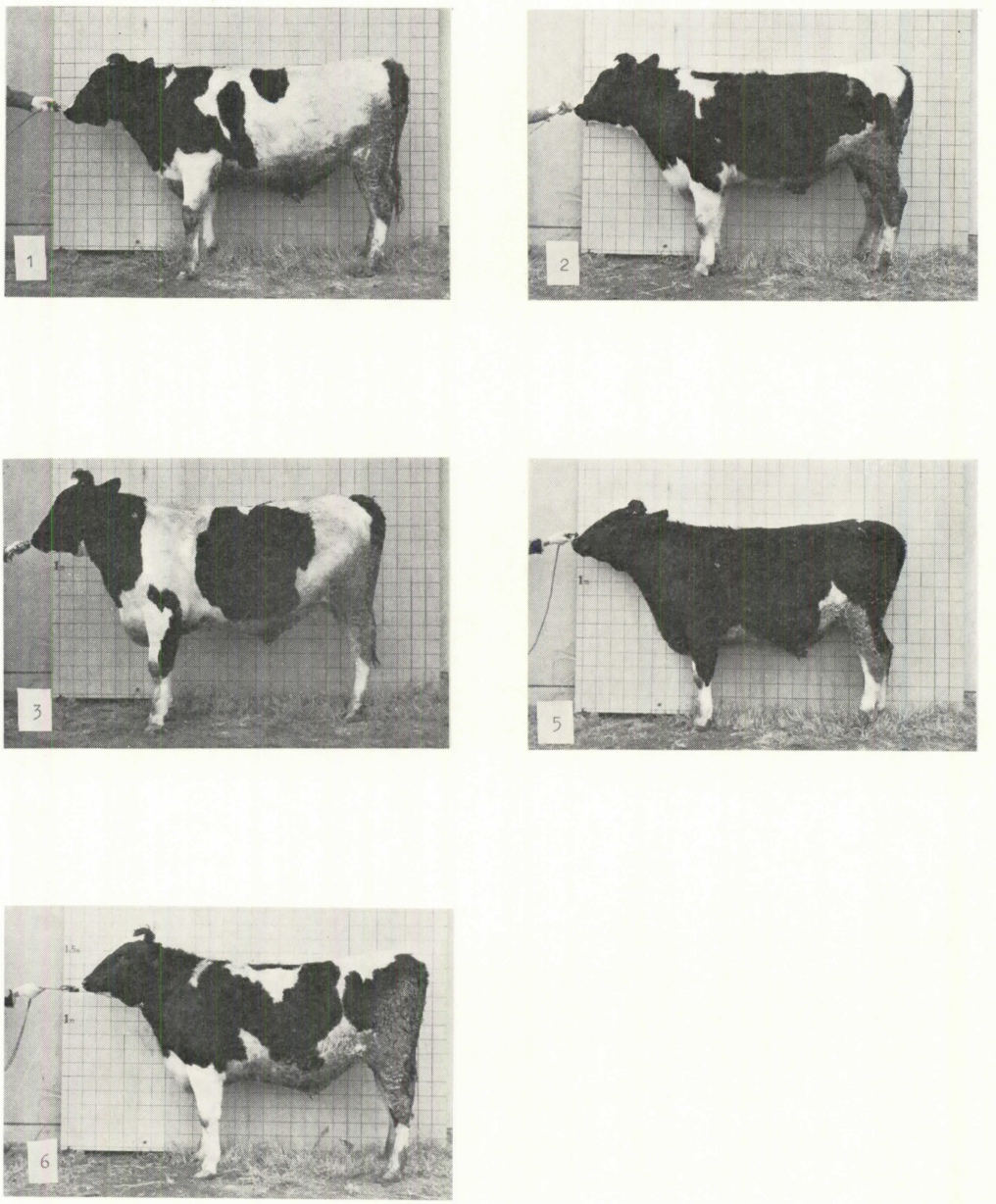

Fig. 2. Dairy beef cattle investigated at the day before slaughtering.

1 : No. 1, 2 : No. 2, 3 : No. 3, 5 : No. 5, 6 : No. 6