A COMPARISON OF THE MILK COMPOSITION OF THE INDIGENOUS SOWS OF NIGERIAN WITH THAT OF THE EXOTIC PURE AND CROSSBRED PIGS

By

ADERAMBO OLUFUNMILAYO A.* and ALMUT. E. DETTMERS

Department of Animal Science
University of Ibadan, Ibadan, Nigeria

SUMMARY

MILK of the indigenous, purebred and crossbred exotic sows were analysed. Total solids content was higher ($P < 0.01$) in the milk of the native sow than in the milk of the others (22.1% vs 20.6%) and higher ($P < 0.01$) in fat content with 9.1% vs 7.2 and 8.1%. Solids-non-fat and protein contents were not different, they were 13.0% vs 11.5 and 12.8% and 7.0% vs 6.1 and 6.3%, respectively. The exception was the milk of the Large White X Landrace crossbred sow which was higher in both than those of the native sow. Lactose content of the milk was the same (4.1, 5.1 and 5.3%). But the concentration of mineral (ash, calcium and phosphorus) differed significantly ($P < 0.01$) among genotypes of sows (0.86, 0.73 and 0.86% ash, 0.320, 0.277 and 0.316%, calcium and 0.196, 0.143 and 0.146% phosphorus).

The milk of all sows combined was richer in every constituent except phosphorus during the dry season. Milk composition was influenced by parity with regard to total solids and phosphorus ($P < 0.01$) and fat and lactose contents ($P < 0.05$). The contents in sow milk was slightly higher than gilt milk.

Nutrient intake by piglets was about the same in both indigenous and exotic pigs due to the richness of milk of the native sows and her smaller litter size in spite of her lower total milk yield.

INTRODUCTION

In comparison with other domestic mammals, the composition of sow milk most closely resemble that of the ewe (Braude *et al.* 1947). It provides 6000 k cal of digestible energy and more than 275g high quality protein per kilogram dry matter (Blaxter 1961; Lucas and Lodge 1961), based on studies of milk from sows of standard breeds in the temperate zone. Much is known about the chemical composition of milk of these breeds in relation to the young's nutritional requirements, their changes during lactation and relationships with the feeding regime.

The milk of sows of the exotic breeds raised in the tropics has not been investigated to any significant extent and nearly nothing so far is known about the milk of the indigenous sow of Nigeria. This report hereby provides some information in that regard.

MATERIALS AND METHODS

Animals

82 pigs were used for the determination of milk constituents. They were made up of 12 each of the Nigerian indigenous breed, Large-white (LW), Landrace (LR), Purebreds; single crosses of these with Duroc boars (D.LW and D.LR) and eleven each of their reciprocal crosses (LW.LR and LR.LW). The pigs were used in a previous study on milk yield and have been adequately described along with the environmental conditions under which they were kept.

Management

This has been previously described.

Milk sampling

Milk was collected from sows after let down of milk was induced by oxytocin as described in a prior paper. Both gilts and sows were used and milk was sampled over an eight-week lactation period during 3 years (1973 — 1975). Colostrum was collected not later than 6 hours after parturition by a manual hand-stripping from all functional teats. Thereafter milk samples were taken weekly on two consecutive days, namely on days 7, 8; 14, 15,

*Present Address: Institute of Agric. Research & Training, P.M.B. 5029, Moor Plantation, Ibadan, Nigeria

ADEBAMBO and DETTMERS

21, 22; 28, 29; 35, 36; 42, 43; and 56, 57 immediately after administration of oxytocin.

Milk Analysis

The first sample was frozen and thawed the following day. The two samples were mixed and analysed fresh in duplicate. Fat percent was determined by the Gerber Test modified for sow milk by Perrin, (1955). Protein content was calculated by multiplying the nitrogen content obtained by the macrokjeldahl method with a factor of 6.38 (A.O. A.C 1970). Total solids were arrived at by difference in weight before and after drying; and solids-non-fat were calculated by subtraction of fat content from the total solids. Ash content was determined by ignition of the dried milk sample and expressed in percent of remaining weight of the original sample. Lactose concentration was obtained by the use of the colorimetric phenol-sulphuric acid method of Barnett and Tawabs (1957) modified by Marier and Boulet (1959).

Finally amounts of phosphorus and calcium were estimated by spectrophotometer and flame photometer. Yields of constituents were computed from the obtained percentages and the total milk yield.

Statistical Analysis

There were seven genotypes, two seasons of farrowing and both gilts and sows.

The eight milk constituents represented the variables, effects of season, genotype, age of sow (parity) and stage of lactation were determined from an analysis of variance using the Hierarchical classification (Singh and Chandhury 1977). The multiple range test was employed to find significant differences between means of genotypes and among weeks of the lactation (Duncan 1955).

RESULTS

Composition of colostrum

Mean contents of the colostrum of each of the seven genotypes of sows and for all sows combined are shown in Table 1.

The colostrum of the Large-white sow was lowest in all constituents determined, the only exception being calcium in which her colostrum was a little higher than that of the Landrace dam. The latter, though also on the lower end of the table, fluctuated more, her colostrum was high in fat, medium in lactose and protein. On the other hand the indigenous pig had the highest total solids, fat content and in phosphorus, second in lactose concentration, third in ash and calcium but rather low in protein and solids-non-fat percentage which makes her colostrum 'richer' in constituents. The crossbred sows ranked in the middle with a tendency towards lower values for total solids, fat, lactose and a higher percentages of solids-non-fat, protein and minerals. Among

TABLE 1

Mean percengates of colostrum constituents

		All+S.E	IND	LW	LR	D.LW	D.LR	LWLR	LR.LW
N		82	12	12	12	12	12	11	11
Total solids*		21.89±0.85	22.84 ^a	19.62 ^{abc}	21.87	21.92	22.66 ^b	21.72	22.65 ^c
Fat..		7.98±0.45	9.22	7.28	8.10	7.63	7.94	7.60	8.01
S.n.f.**		13.79±0.53	13.62	12.35 ^{ab}	13.83	14.12	14.71 ^b	13.91	14.69 ^a
Protein*		7.91±0.35	7.53	6.97 ^a	7.81	7.38	8.70	8.16	8.93 ^a
Lactose*		5.18±0.10	5.31	4.66 ^a	5.28	6.02 ^{abc}	5.18	4.85 ^c	4.75 ^b
Ash*		0.77±0.10	0.78	0.71 ^a	0.71 ^a	0.75	0.83 ^{ab}	0.81	0.83 ^{ab}
Calcium		0.14±0.001	0.27	0.21	0.19	0.23	0.22	0.28	0.29
Phosphorus*		0.14±0.002	0.17 ^a	0.11 ^a	0.13	0.16	0.14	0.15	0.12

a-c — Means with same superscript differ from each other
 ** — P 0.01 and * — P 0.05.

MILK COMPOSITION OF PIGS

the crossbred sows it appears that colostrum of the crosses with Large-white female ranked higher in most constituents than those from Landrace female. This was in contrast to the purebred dams. Most of the genotype differences were significant (Table 2). Season of farrow influenced colostrum composition regarding total solids ($P < 0.05$) fat, protein lactose and calcium ($P < 0.01$) by being higher during the dry season. There were no appreciable differences due to age of dam (parity).

Chemical Composition of Milk

Mean chemical composition of milk from the seven different genotypes is given in Table 3. The milk of the indigenous sow was, with the exception of lactose content, in the first position for total solids, fat, ash, phosphorus, and in the second position for solids-non-fat.

protein and calcium. In contrast to the colostrum content the milk of the exotic purebreds, was lowest in every constituents except for the lactose in the milk of Landrace sow. The crossbred sows were leading in solids-non-fat, protein, lactose and calcium contents especially those sows having Large white as one of the parent in the cross. Genotypic differences were significant ($P < 0.01$) for total solids fat and minerals (Table 4). Seasonal influences on the milk were more pronounced and all constituents except phosphorus were of a higher concentration in the milk during the dry season. These differences were significant for total solids, protein, phosphorus ($P < 0.01$) and fat, solids-non-fat and calcium ($P < 0.05$). The difference in the milk of the indigenous pigs was not as pronounced with 2 — 8% difference in the total solids content, 1.6% for fat and 1.2% for solids-non-fat and 0.9% for

TABLE 2

Mean square analysis for colostrum content

Source of Variation	Season (a)	Breed s/s (b)	Age s/d (a)	Error variance
d.f.	1	12	14	51
Total solids	26.689*	17.602*	5.423	5.783
Fat	38.864**	6.487	0.355	3.815
S.n.f.	0.464	11.912**	3.289	3.423
Protein	7.517*	8.644*	1.248	2.397
Lactose	3.420**	1.688*	1.067	0.662
Ash	0.02	0.013*	0.011	0.010
Calcium	0.046**	0.012	0.007	0.007
Phosphorus	0.001	0.004*	0.001	0.002

** $P < 0.01$ and * $P < 0.05$

TABLE 3

Chemical composition of the milk (%)

Component	IND	LW	LR	D.LW	D.LR	LW.LR	LR.LW
N	12	12	12	12	12	11	11
Total solids**	22.09ab	18.82ac	19.30b	20.09	20.97c	20.97c	20.61
Fat**	9.09ab	7.18b	7.15a	7.63	8.33	8.33	8.30
S.n.f.	12.98	11.72	11.25	12.52	12.66	13.27	12.93
Protein	7.00	6.09	6.16	6.22	6.42	7.01	6.74
Lactose	5.14	4.93	5.35	5.56	5.45	5.16	5.13
Ash**	0.86ab	0.73bd	0.73ac	0.75	0.80	0.84cd	0.83
Calcium**	0.330b	0.285	0.268ab	0.349a	0.308	0.307	0.298
Phosphorus**	0.196abcdef	0.139a	0.147d	0.151e	0.146c	0.160f	0.141b

a-f — Means with same superscript are different from each other

** — $P < 0.01$

TABLE 4

Analysis of variance for milk constituents (%) by season, genotype, parity and stage of lactation

Sources of variation	Season (s)	Breed w/s (b)	Age w/b (a)	Lactation stage w/a (1)	Error variance
d.f.	1	12	14	196	432
Total solids	39.95**	79.57**	11.79**	7.05**	5.14
Fat	9.64*	31.63**	5.33*	3.64	2.59
S.n.f.	13.24*	14.31	5.76	2.24	2.39
Protein	8.32**	7.31	2.47	0.84	0.87
Lactose	0.30	4.37	2.87*	0.80	0.92
Ash	0.002	0.129**	0.028	0.016**	0.008
Calcium**	0.029*	0.045**	0.008	0.010**	0.005
Phosphorus	0.014**	0.023**	0.003**	0.006**	0.008

** — $P < 0.01$ and * $P < 0.05$.

protein in favour of the dry season. Milk composition was also influenced by age of the dam at highly significant levels ($P < 0.01$) for total solids and phosphorus content and ($P < 0.05$) for fat and lactose. The graphs of the milk constituents are presented in Figs 1 — 3. These graphs clearly show that after an initial

high colostral value of all the contents except for calcium and phosphorus in all the breeds and lactose in the indigenous breed, there was definitely a decline followed by a gradual increase in the contents which indicated a concentration of the constituents as the milk production decreases.

Fig 1 Content (%) of total solids (TS), solids - not - fat (Snf) and fat (f) of milk from indigenous, crossbred and purebred sows.

Fig 3 Content (%) of ash (A), calcium (Ca) and phosphorus (P) of milk from indigenous, crossbred and purebred sows

Table 5 gives weekly means of milk constituents (%) for all genotypes combined, as well as the comparative values for colostrum. Although there is a rise in concentration over the course of the lactation period for most components these are significantly different only ($P < 0.01$) between the early and late weeks for total solids and the minerals. There are little or no fluctuations in protein and lactose content.

Yield of Milk Nutrients

The total yield of milk nutrients was calculated from the sum of estimated weekly milk yields and percentages obtained from chemical analyses. The means of the total yields were given in Table 6 for each genotype.

The indigenous sow had the lowest yields ($P < 0.01$) of total solids, fat, proteins, lactose, and ash. Exotic purebred sow averaged about 3kg higher yields of

TABLE 5

Mean weekly milk composition (%) of all genotypes combined

Component	Colo-strum	1	2	3	4	5	5	7	8
Total solids **	21.89	19.22b	19.19a	19.70	19.95	20.56	21.25	21.36	22.02ab
Fat ..	7.98	7.13	7.20	7.60	7.90	8.09	8.56	8.58	8.08
S.n.f. ..	13.79	11.96	12.00	12.22	12.19	12.44	12.70	12.77	14.21
Protein ..	7.91	6.11	6.20	6.30	6.34	6.33	6.58	6.64	6.94
Lactose ..	5.18	5.21	5.09	5.25	5.08	5.34	5.35	5.30	5.36
Ash** ..	0.77	0.72ad	0.73be	0.73cf	0.76	0.79	0.81	0.85def	0.86abc
Calcium **	0.240	0.250ac	0.262b	0.292	0.294	0.318	0.328	0.352ab	0.344c
Phosphorus**	0.138	0.140a	0.144c	0.142b	0.153	0.151	0.166	0.167	0.178abc

a-f — Means with same superscript differ from each other

** — $P < 0.01$.

Fig 3 Content (%) of ash (A), calcium (Ca) and phosphorus (P) of milk from indigenous, crossbred and purebred sows

Table 5 gives weekly means of milk constituents (%) for all genotypes combined, as well as the comparative values for colostrum. Although there is a rise in concentration over the course of the lactation period for most components these are significantly different only ($P < 0.01$) between the early and late weeks for total solids and the minerals. There are little or no fluctuations in protein and lactose content.

Yield of Milk Nutrients

The total yield of milk nutrients was calculated from the sum of estimated weekly milk yields and percentages obtained from chemical analyses. The means of the total yields were given in Table 6 for each genotype.

The indigenous sow had the lowest yields ($P < 0.01$) of total solids fat, proteins actose, and ash. Exotic purebred sow averaged about 3kg higher yields of

TABLE 5

Mean weekly milk composition (%) of all genotypes combined

Component	Colo-strum	1	2	3	4	5	5	7	8
Total solids **	21.89	19.22b	19.19a	19.70	19.95	20.56	21.25	21.36	22.02ab
Fat ..	7.98	7.13	7.20	7.60	7.90	8.09	8.56	8.58	8.08
S.n.f. ..	13.79	11.96	12.00	12.22	12.19	12.44	12.70	12.77	14.21
Protein ..	7.91	6.11	6.20	6.30	6.34	6.33	6.58	6.64	6.94
Lactose ..	5.18	5.21	5.09	5.25	5.08	5.34	5.35	5.30	5.36
Ash** ..	0.77	0.72ad	0.73be	0.73cf	0.76	0.79	0.81	0.85def	0.86abc
Calcium **	0.240	0.250ac	0.262b	0.292	0.294	0.318	0.328	0.352ab	0.344c
Phosphorus**	0.138	0.140a	0.144c	0.142b	0.153	0.151	0.166	0.167	0.178abc

a-f — Means with same superscript differ from each other

** — $P < 0.01$.

MILK COMPOSITION OF PIGS

TABLE 6

Yield of milk nutrients (kg) by genotype

Genotype	Total solids	Fat	Protein	Lactose	Ash
IND	16.32abcdef	6.71abcd	5.18abcde	3.79abcde	0.64abcd
LW	28.46d	10.89d	9.07c	7.41d	1.10c
LR	25.66e	9.48	8.26e	6.96e	0.98
D.LW	28.76c	10.97c	8.80d	7.97b	1.08d
D.LR	38.28a	12.74a	9.81a	8.40a	1.24a
LW.LR	25.50f	10.09	8.17	6.27	0.98
LR.LW	30.65b	12.08b	9.67b	7.58	1.20b
	**	**	**	**	**

a-f = Means with same superscript differ from each other

** = $P < 0.01$.

protein, fat and lactose and 10kg more total solids and about 1/3kg ash more. They were exceeded by the crossbreds but the differences were not significant. The low yields of total nutrients of the native sow had of course to do with her low total milk yield of only 74kg as compared to 130 — 148kg of the other sows giving an average daily yield of 291g total solids for the indigenous, 92.5g protein and 120g fat as compared to the highest value of 576g, 227.5 and 175g respectively in the exotic.

In relation to the nutrient intake by the litter (Table 7) there was no difference in protein and fat intake between the indigenous and other genotypes but was slightly lower in the lactose intake ($P < 0.05$) and total solids ($P < 0.01$) with regard to one of the crosses.

A striking relationship could be drawn from the yield of nutrients per kg dry

matter. Absolutely the indigenous pig produced the lowest amount of protein, fat and total solids per day ($P < 0.01$) but in terms of dry matter, she produced 412g fat compared to 370 — 403g and 317g protein compared to 306 — 334g per kg dry matter of milk of the other genotypes (Table 8).

DISCUSSION

The total solids, protein and solids-non-fat content of this study with 21.9, 7.9, and 13.8% respectively was lower than values between 25 — 31, 12 — 17 and 17.2% reported from the temperate countries by some workers (Pond *et al*, 1962; Salmon-Legagneur and Gueguen 1962; Earle and Stevenson 1965; Elliot *et al*, 1971 and Fahmy, 1972) but with range of 19 — 25, 6.1 — 9.7 and 12.2 — 15.3% reported by others (Neuhaus Von, 1961; Bowland, 1966). Fat, lactose, ash and phosphorus content agreed with other

TABLE 7

Mean daily nutrient intake (g) per piglet

Genotype	Litter size	Total Solids	Fat	Protein	Lactose	Ash
IND	4.83	67.22a	25.96	20.10	14.00a	2.36a
LW	6.93	79.03	27.51	22.68	19.10	2.83
LR	5.08	75.54	33.35	29.20	24.48a	3.46a
D.LW	7.97	71.74	24.04a	19.50a	17.46	2.42
D.LR	7.68	83.74	30.34	23.30	19.52	2.88
LW.LR	6.96	93.37a	37.26a	30.36a	16.09	2.51
LR.LW	7.04	87.40	32.84	25.10	19.23	3.04
		**	*	**	*	*

a = Means differ from each other.

** = $P < 0.01$ and * $P < 0.05$

ADEBAMBO and DETTMERS

TABLE 8

Daily yield of total solids, fat and protein per sow in gram and per kg dry matter

Genotype	Daily output		Protein	g/kg Dry matter	
	TS	Fat		Fat	Protein
IND	291.4a	119.8a	92.5a	411.5	316.9
LW	508.2	196.5	162.0	381.5	323.6
LR	458.2	169.3	147.5	370.5	319.2
D.LW	514.6	195.9	157.1	379.8	309.6
D.LR	576.4	227.5	175.2	397.2	306.2
LW.LR	455.4	180.2	145.9	397.2	334.3
LR.LW	547.3	215.7	172.6	402.7	327.0
	**	**	**		

a = this mean differs from all the others

P < 0.01

1 Yield g/kg dry matter — 100

$\frac{\text{X\% nutrient}}{\text{\% TS}}$

reports. The calcium concentration was high in the colostrum here with 0.24% as against values of 0.05 (Fahmy 1972) and 0.05 — 0.08 (Neuhaus Von 1961 Miller, 1967, Elliot *et al.*, 1971). It is known that the diet of the sow has an effect on the composition of colostrum and milk (Holden *et al.* 1968). The low concentration especially in protein of the colostrum could have been caused by the low protein content in the ration fed to the dam prior and during lactation.

In most studies however, a few animals were used of one single breed. Only Heidebrecht *et al.* (1951) compared three breeds, the Hampshire, Duroc and Chester white and they found consistent differences among breeds, but noted also large variations among individuals within breed, agreeing with a recent paper by Fahmy (1972) who compared seven breeds in Canada.

When comparing the lactation trends obtained in this study with those of other workers, the greatest differences were in the fat content. Willett and Maruyama (1946) reported an increase of fat with advancing lactation while others found an appreciable decrease after an initial rise (Bowland *et al.*, 1966, Braude *et al.*, 1947; Perrin, 1954). The rising fat content reported here may be connected with the sharp decline in yield from about the third week of lactation. The daily

yield of protein on dry matter basis was higher in this study than reported elsewhere (Blaxter, 1961; Lucas and Lodge, 1961) and probably due to the generally low yields in all the sows studied.

Results of this investigation show that differences in chemical composition of sow milk existed between breeds and genotypes. They agree with findings by Egesimba (1974) who studied another group of pigs at Ibadan. He however, obtained much higher values for the milk of the indigenous pigs than for other breeds, and the composition of milk from crossbred sows was close to that of the indigenous. However, this study was based on comparatively few animals. Breed differences was also reported by others working with standard breeds of swine in temperate regions (Smith, 1959; Allen and Lasley, 1960; Fahmy, 1972). It can be stated that the indigenous sow, due to her 'rich' milk but smaller litter size, does provide about the same amount of milk nutrients for her piglets as the exotics.

The chemical composition of sow milk at various stages of lactation was studied because it is of importance with regard to the nutrition of the young pigs. The quality of the milk can be influenced by feeding and management of the dams especially with regard to the protein content (FEY, 1958; Holden *et al.*, 1968).

MILK COMPOSITION OF PIGS

The relatively low total milk yield of the indigenous and for that matter also of the exotic — pigs in this study combined with higher concentrations of constituents is comparable with dairy animals in the tropics. Yields of the latter also are depressed in the tropical environment, and the zebu cow milk for example has a considerably higher fat content than other breeds of cows.

The 'richness' of the milk of the native sow and the availability of sufficient amounts of nutrients per piglet can be viewed as a balance for her low total yield so that in the end (on dry matter basis) she did not differ from other breeds. One can deduce therefore that the indigenous sow of Nigeria is well adapted and able to supply her piglets with the required nutrients through her milk.

There is a need now to study whether milk yield and composition can be increased and/or changed when indigenous pigs are raised in confinement and will have larger litters, as shown by Fetuga *et al.* (1976) of which more pigs survive. These aspects have to be considered if indigenous pigs are to be utilized in pig and pork production. It will also be necessary to investigate relationships between dam and litter performance in order to determine suitable selection and breeding procedures when indigenous pigs are to be utilized.

REFERENCES

- ALLEN, A. D. and J. F. LASLEY. 1960. Milk production in sows. *J. Anim. Sci.* 19, 150-155.
- A.O.A.C., 1970. Association of Official Agricultural Chemists. Official Methods of Analysis. 11th ed. Washington, D.C.
- BARNETT, A. J. G. and G. A. A. TAWABS. 1957. Rapid method for the determination of lactose in milk and cheese. *J. Sci. Food Agr.* 8, 437-441.
- BLAXTER, K. L. 1961. Milk, the mammary gland and its secretion. In: *Milk, the mammary gland and its secretion*. KONSKE, R. and A. T. COWIE (eds). Academic Press. Vol. II, P. 305.
- BOWLAND, J. P. 1966. Swine milk composition. In: *Swine in Biomedical Research*. Frayn Printing Co., Seattle, Wash. PP. 97-107.
- BRAUDE, R., COATES, M. E., HENRY, K. M., KONSKE, R., ROWLAND, S. J., THOMPSON, S. Y. and D. M. WALKER. 1947. A study of the composition of sow's milk. *Brit. J. Nutr.* 1: 64-77.
- DUNCAN, D. B. 1955. Multiple range and multiple F-tests. *Biom.* 11 1-42.
- EARIE, L. P. and J. W. STEVENSON. 1965. Relation of dietary zinc to composition of sows colostrum and milk. *J. Anim. Sci.* 24, 325-328.
- EGESIMBA, J. O. D. 1974. Comparative studies of the protein, lactose, fat, ash and major mineral contents of milk of different breeds of sows. Student research project, Department of Animal Science, University of Ibadan.
- ELLIOT, R. F., VANDERNÖCT, G. W. GILBREATH, R. L. and H. FISHER. 1971. Effect of dietary protein level on composition and changes in sow's milk and colostrum. *J. Anim. Sci.* 32, 1128-1137.
- FAHMY, M. H. 1972. Comparative study of colostrum and milk composition of seven breeds of swine. *Can. J. Anim. Sci.* 52, 621-627.
- FETUGA, B. L., BABATUNDE G. M. and V. A. OYENUGA (1976). Performance of the indigenous pigs of Nigeria under intensive management conditions. *Niger. J. Anim. Prod.* 3, 148-161.
- FEY, H. 1958. The estimation of milk in the "Edelschwein". Diss., University of Bern.
- HEIDEBRECHT, A. A., MCVICAR ROSS, O. B. and C. K. WHITEHAIR. 1951. Composition of swine milk in major constituents and carotene, Vitamins A and C; *J. Nutri.* 44, 43.
- HOLDEN, P. J., LUCAS, E. W., SPEER, V. C. and W. V. HAYS. 1968. Effect of protein level during pregnancy and lactation on reproductive performance in swine. *J. Anim. Sci.* 27, 1587-1590.
- LUCAS, I. A. M. and G. A. LODGE. 1961. The nutrition of the young pig. A review. *Tech. Comm. No. 22*. Bur. Anim. Nutr; Rowett Institute Aberdeen.
- MARIER, J. and M. BOULET. 1959. Direct analysis of lactose in milk serum. *J. Dairy Sci.* 42, 1390-1391.
- MILLER, E. R. 1967. Minerals for swine Prod. *Natural Feed Ingredients Assoc.* Osgo. Beach, Mo. P. 49.
- NEUHAUS, A. VON. 1961. Die Milchleistung der Sau und die Zusammensetzung und Eigenschaften der Saumilch. *Z. Tierz. Zucht. biol.* 75, 160-169.
- PERRIN, DAWN, R. 1954. Composition of sow milk during the course of lactation. *J. Dairy Res.* 21, 55-62.
- PERRIN, DAWN, R. 1955. Chemical composition of colostrum and milk of the sow. *J. Dairy Res.* 22, 103.
- POND, W. G., VAN VLECK, L. D. and D. A. HARTMAN. 1962. Parameters for milk yield and for percentage ash, dry matter, fat and protein in sows milk. *J. Anim. Sci.* 21, 293-297.
- SALMON-LEGAGNEUR, E. and L. GUEGUEN. 1962. Evolution de la chimique du colostru chez la truie. *Ann. Biol. Anim. Biochem. Biophys* 2, 229.

SMITH, D. M. 1959. The yield and composition of milk from sows fed varying proportions of separated milk and concentrates. NZ J. Agr. Res. 2, 1057.

WILLIET, E. L. and C. MARUYAMA. 1946. The effect of intake of garbage fat upon fat

content of sow milk. J. Anim. Sci. 5, 365-370.

SINGH, B. K. and B. D. CHAUDHURY. 1977. Biometrical methods in quantitative genetic analysis kalyani publishers New Delhi Ludhiana.