Porcine Neonatal Nutrition: Effect of Weaning Time on the Maturation of the Serum Protein Profile[1]

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In a previous publication the point was stressed that pigs are born deficient in blood serum proteins (Lecce and Matrone, '60). Mainly, piglet's serum lacks γ-globulin and is extremely low in albumin and β-globulin. The major serum proteins, accounting for 70 to 80%, migrate in the α-globulin zone and are not precipitated by trichloroacetic acid. In addition, piglet's serum contains less than half the adult's total serum protein. This serum protein profile of birth was termed "immature" and the adult profile, "mature." The sequential changes involved in developing from the immature to the mature profile found in piglets were reminiscent of those reported to occur in fetal goats and sheep (Barboriak et al., '58a, '58b; Meschia, '55).

Nursing pigs had immediate changes in blood serum proteins, and in less than two weeks the serum profile was similar to an adult profile. The "maturation process" was delayed approximately a week in the pigs fed cow's milk, two weeks in those fed an artificial milk, and no maturation was seen in pigs eating an "amino acid milk" (Lecce and Matrone, '60).

The sow, through her mammary secretions, seemed to supply a factor(s) that promoted rapid, sequential changes in the piglet's serum proteins; and the piglet had a latency in the development of a mature serum profile unless he had access to this factor(s). The purpose of the experiments reported herein was to gain insight into the means whereby the sow influences the maturation of the serum protein profile. To pursue this goal, it was decided to define the amount of nursing (degree of exposure to sow's maturation factor(s)), required to overcome the latency in the piglet's protein metabolism. This was done by determining the extent of the serum protein changes occurring before the nursing piglet could be weaned from sow's milk to other food, without delaying the maturation process.

EXPERIMENTAL

Unless indicated to the contrary in the figures, pigs (with the exception of those weaned at 14 days) were bled at birth and at one, 4, 8, 14, and 21 days of age. Those pigs weaned at 14 days were bled approximately every 4 days until the experiment terminated at 52 days. Blood was analyzed for serum proteins, using paper electrophoretic techniques. The total serum proteins and the amount of the proteins precipitated by trichloroacetic acid (TCA) also were determined. Thus, three measurements characterized the serum protein profile: (1) milligrams per milliliter of albumin, α-, β-, and γ-globulin; (2) percentage of total protein; and (3) optical density (OD) of TCA precipitate. Details of the blood analyses, as well as the diets and methods of securing, handling and feeding the piglets, have been published previously (Lecce and Matrone, '60).

A total of 22 pigs from 5 litters was used in this study. Each pig was assigned randomly to the following treatments:

1. Eight pigs nursed the sow for the first 24 hours only; then 4 were switched to the amino acid diet[2] and 4 to the fortified cow's milk diet.

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[2] Enzymatic casein and lactalbumin hydrolyzate, Nutritional Biochemicals Corporation, Cleveland.

2. Four pigs were allowed to nurse their sow for the first 4 days before weaning two pigs to the amino acid diet and two to the fortified cow's milk diet.

3. Six pigs nursed their sow for the first 8 days before changing two pigs to the amino acid diet and 4 pigs to the fortified cow's milk diet.

4. Four pigs nursed their sow for the first 14 days before weaning two pigs to the amino acid diet and two pigs to cow's milk diet.

RESULTS

As noted before (Lecce and Matrone, '60), pigs nursing the sow had rather intense, immediate, and continuous changes

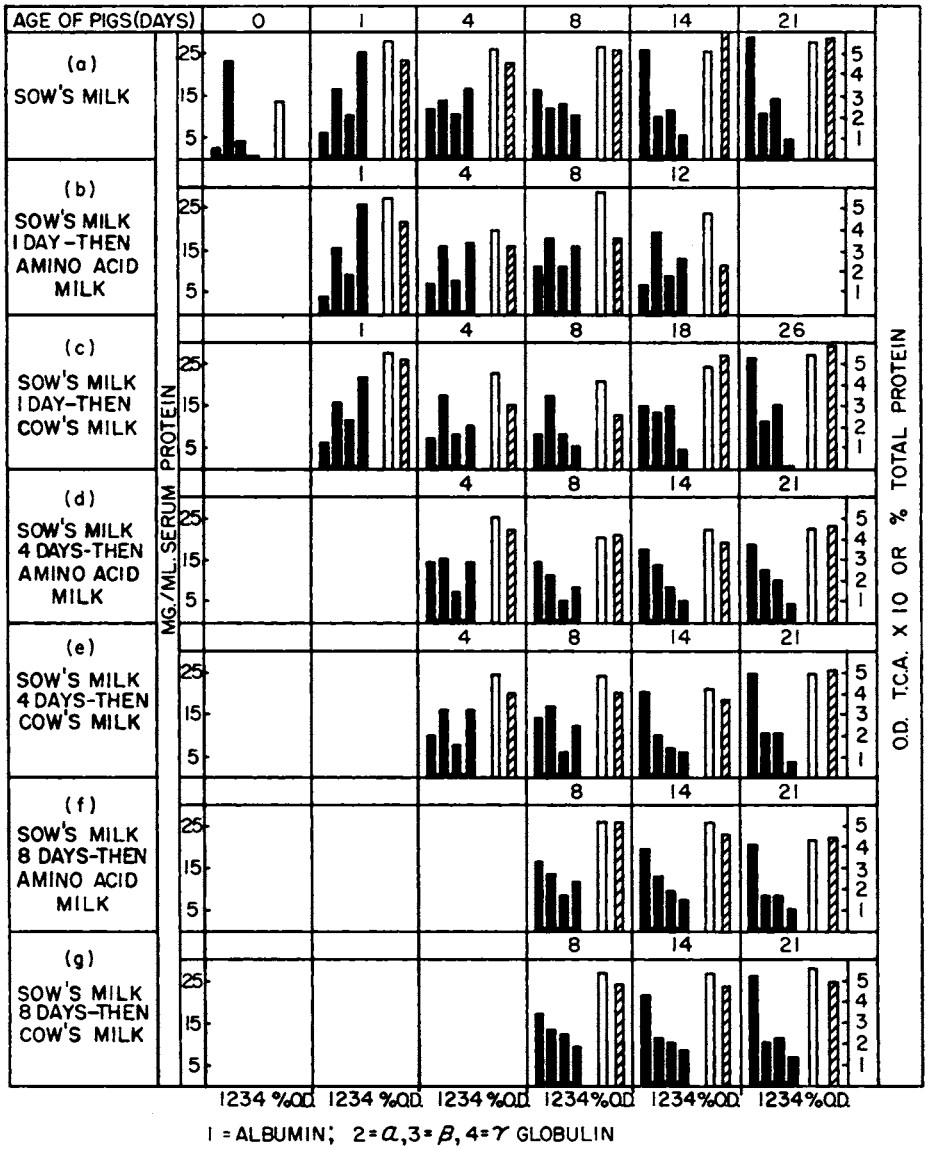

Fig. 1 The effect on the maturation of the serum protein profile of weaning piglets at one, 4 and 8 days to an amino acid diet and a cow's milk diet. OD indicates optical density of trichloroacetic acid precipitate; % indicates percentage of protein.

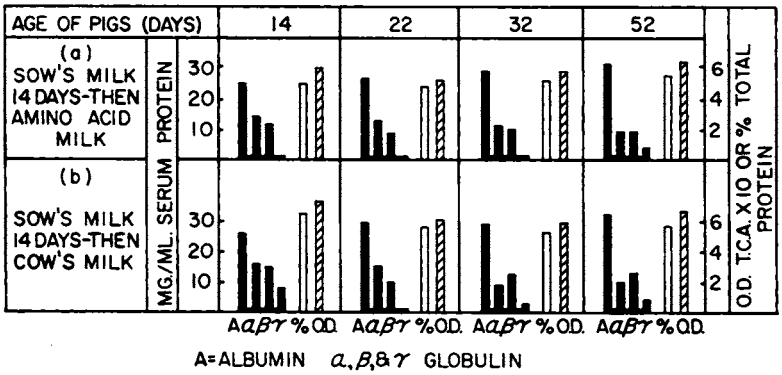

Fig. 2 Serum protein profiles of pigs weaned at two weeks to an amino acid diet and a cow's milk diet. OD indicates optical density of trichloroacetic acid precipitate; % indicates percentage of protein.

in serum proteins (fig. 1a). By 14 days the piglets had serum profiles similar to that of an adult.

Pigs allowed to nurse the sow for the first 24 hours (fig. 1b) and then switched to the amino acid milk did not hold the advantages of the immediate changes occurring from this one day of nursing, since the maturation process seemed to stop and even regressed. Half of the pigs that were changed over to the amino acid diet died by the 7th day, and all were dead by the 12th day. With the pigs switched to cow's milk (fig. 1c), only one out of 4 died (7th day). The serum protein maturation process also seemed to stop and then exhibit a latent period similar to that seen in pigs fed solely on the cow's milk from the time of birth (Lecce and Matrone, '60). The delay in the maturation of the serum protein profile in those pigs weaned to cow's milk at 24 hours was evidenced by a stabilized low ratio of albumin to α-globulin occurring in the first 8 days (fig. 1c) and by the similarity of the 18-day serum profile with the 8-day serum profile in pigs continuously nursing the sow (fig. 1a).

In pigs allowed to nurse the sow for 4 days, this delay in the development of serum proteins was not evident. Both the pigs weaned to amino acid milk (fig. 1d) and cow's milk (fig. 1e) maintained the changes that occurred while nursing the sow for the first 4 days and continued without apparent delay to develop a mature-looking serum protein profile. However, the albumin of the pigs switched to the amino acid diet seemed to have been stabilized at less than maximum level (19 mg/ml at 21 days). In contrast, pigs fed cow's milk did not have this limitation in amount of albumin (25 mg/ml at 21 days).

Much the same type of reaction as seen at 4 days occurred in the pigs nursing the sow for 8 days. The 8-day maturation changes were maintained, and serum protein development continued, but again the pigs weaned to the amino acid diet (fig. 1f) had less albumin (21 mg/ml at 21 days) than the pigs changed over to cow's milk (26 mg/ml at 21 days) (fig. 1g).

With those pigs nursing the sow for two weeks before weaning, their mature profile remained grossly unchanged for the 38-day testing period whether fed the amino

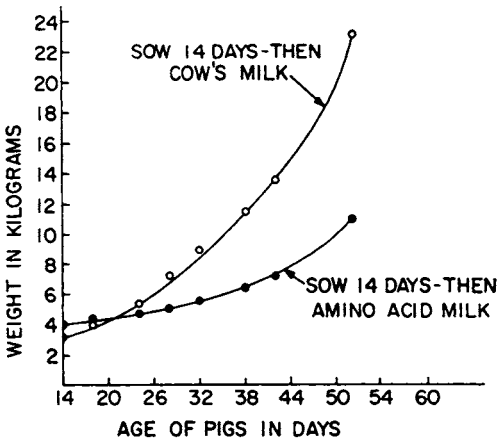

Fig. 3 Weight gains of pigs weaned at two weeks to an amino acid diet and a cow's milk diet.

acid diet (fig. 2a) or the cow's milk diet (fig. 2b). The pigs fed the amino acid diet, however, had diarrhea continuously and gained about half as much weight as their littermates fed milk (fig. 3).

DISCUSSION

From the data in this study and a previous study (Lecce and Matrone, '60), it appears that the proteins in sow's colostrum and milk are the source for the immediate changes observed in the maturing piglet's serum protein profile. These changes, no doubt, come from the piglet's ability to absorb, unaltered, proteins from the colostrum in the first 36 hours of its life (Lecce et al., '61). Having accounted for these immediate changes, however, the data herein indicate that beyond these initial changes, caused by absorption of whole proteins, there is still something unique about the sow's lacteal secretion that continues to influence changes toward a mature serum protein profile. This is inferred from the results obtained from the pigs that nursed the sow for one day and were switched to cow's milk and amino acid milk. Even though immediate changes occurred in the serum protein profile of these pigs, they were neither able to maintain these changes nor continue the serum protein maturation process without delay. Moreover, the amino acid diet did not support the life of the piglets in this nursing group.

After having nursed the sow for 4 days, however, the piglet apparently had developed sufficiently so that when weaned to cow's milk, maturation of the serum protein profile continued uninterrupted. Littermates weaned to the amino acid milk at 4 days seemed unable to utilize this food for further maturation as well as the pigs fed cow's milk (judging from the slower increase in serum albumin in the amino acid group). However, the amino acid diet did support the piglet's life at this stage of his physiologic maturity. Similar results were obtained for the piglets weaned at 8 days to cow's milk and amino acid milk. These results, plus the fact that pigs survived for at least 38 days without apparent changes in the mature serum protein profile when fed the amino acid diet, indicate that once a certain stage of maturity is reached, the amino acid diet is adequate for supporting life and maintaining the existing serum protein profile.

It might be concluded from these and other data (Lecce and Matrone, '60; Lecce et al., '61) that the sow influences the maturation of the piglet's serum protein profile in two ways, the first of which is by furnishing the proper physiologically active proteins that are absorbed unaltered by the piglet. This would constitute the first phase of the maturation. Secondly, the sow uniquely functions in maturation by supplying a factor(s) or balanced nutrients that provide for continuing changes in the piglet's serum proteins. This might be termed the second phase of maturation. The means whereby the sow functions in this second phase are not as clearly visualized as the means in the first phase are. However, a clue might be gleaned by contrasting the data obtained from the pigs weaned at one, 4 and 8 days (representing various stages in a maturing serum profile) to the amino acid milk with those weaned to the cow's milk. The less satisfactory results seen in piglets fed the amino acid milk imply that the protein needs of the piglet involve more than a supply of "amino acids." The possibility is raised that specific kinds of proteins (particularly rich in sow's milk) supply key peptide moieties required for protein synthesis. Future work will be designed to test this possibility.

SUMMARY

Pigs were weaned at one, 4, 8 and 14 days to fortified cow's milk and to an "amino acid" milk. Those weaned to cow's milk at one day experienced a delay in the maturation of their serum protein profile, even though marked changes toward a mature serum profile already had begun. Their response in serum protein development resembled the latent response seen in pigs weaned at the time of birth to cow's milk. Pigs weaned at one day to the amino acid milk showed an arrested

immature serum protein profile and eventually died.

Pigs weaned to cow's milk after 4 days of nursing were sufficiently mature physiologically so that no delay in serum protein development was observed. Pigs weaned at 4 days to the amino acid milk also developed a mature serum profile, although albumin did not reach as high a level as in the pigs fed cow's milk.

Results similar to those obtained in the pigs weaned at 4 days were seen in the pigs weaned at 8 days to cow's milk and amino acid milk.

Pigs, with mature serum protein profiles, weaned at 14 days maintained these profiles whether fed cow's milk or amino acid milk.

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