Effects of Feeding Fat During Pregnancy and Lactation on Growth Performance, Milk Compositions and Very Low Density Lipoprotein Compositions in Rats

Loh, TC[1], Nur Shukriyah, MH[1], Foo, HL[2], Zurina, AW[1] and Tan, BK[1]

Department of Animal Science
Faculty of Agriculture
[1]Department of Biotechnology[2]
Faculty of Science and Environmental Studies
University Putra Malaysia,
43400 UPM Serdang, Selangor,
Malaysia

Telephone Number of Corresponding Author: 03- 8946 6899
E-mail of Corresponding Author: tcloh@agri.upm.edu.my

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Introduction

Rats and pigs experience a hyperlipidaemia mostly due to a rise in very low density lipoprotein-triacylglycerol, in late pregnancy. The rats may be a good model for pig pregnancy and lactation because the manipulation of food intake and milk yield is similar to that in pigs than in other species. Changes in the nature and quantity of plasma lipids occurring during pregnancy and lactation can be expected to have implications for the nutrition and development of the neonate. This is particularly important in neonate with very low energy reserves and which must be therefore depend more heavily upon milk for its energy requirements in early life. However, provision of low quality milk or inadequate amount of milk to each individual from large litter size (e.g. pigs or rats) may cause high mortality before weaning. Preweaning mortality in neonates has always represented significant economic wastage especially in agricultural species. For example, in pigs, preweaning mortality is typically about 12% and remains a major problem in pig production. The effects of dietary fats on neonatal growth, maternal weight, maternal body composition and their lipoprotein can vary widely. Slow progress has been made in the understanding of the factors influencing the probability of survival and death. This study will help to explain and predict the variation in responses to different diets as well as improve efficiency of nutrient use.

Materials and Methods

Thirty-three female Sprague-Dawley rats weighing 188-200g at 12 weeks of age were used in this study. They were housed individually in plastic cages in a temperature-controlled room (26±2°C) with a 12-h light dark cycle. They were randomly assigned to three numerically equal groups. Each of 11 dams: LF (2.5g fat/100g diet), MF (7.5g fat/100g diet) and HF (15g fat/100g diet). All diets had the same energy density and supplied 15.20kJ of digestible energy per gram of dry diet. All compositions of the different diets are presented in Table 1. Fat contributed 3%, 22% and 40% of total energy to the LF, MF and HF diets, respectively. Rats had free access to diet and water. All the rats were adapted to the respective diets for a week before mating. Body weight and feed intake were recorded every week for 7 weeks: 3 weeks of pregnancy and 4 weeks of lactation. The animals weighing 200-280g at 14 weeks of age were mated. Day 1 of pregnancy was indicated by the day on which sperm was identified in vaginal smears, whereas day 1 of lactation was designated on the day of parturition. Litters were weighed and adjusted to 8 pups per dam. No sex differentiation was done. Litter were weighed weekly throughout the lactation period. Milk samples were collected on days 5, 10 and 15 of lactation from 11 rats of each dietary group. The litters were separated from their dams for a period of 4 hours before milking. Milk composition can be affected if there is a longer period of separation (Keen et al., 1980). Milking was done manually from all teats after intraperitoneal injection of oxytocin (4UI) under moderate pentobarbital anaesthesia (35mg/kg BW). All the milk samples were kept at –20°C until further analysis. Milk protein concentration was determined by the method of Lowry (1951). Lipid concentrations were estimated as described by Brigham et al (1992).Blood samples were collected from tail vein on day 0, 7 and 14 of pregnancy and days 7 and 14 of lactation period. All the rats were handled gently and carefully. Very low density lipoprotein TG concentrations were determined as previously described (Tan et al., 2000; Loh et al., 2002). The results are presented as mean and its standard error of difference (s.e.d.). Differences between groups were analysed by Student's t test for independent samples (Minitab, 1995). Differences of $p<0.05$ were considered significant.

Results and Discussion

The average body weights from various treatment groups of dams increased steadily during pregnancy and decreased after parturition (Figure 1). however no differences ($p>0.05$) were observed between groups throughout pregnancy and lactation.

Body weights for HF pups were significantly higher ($p<0.05$) than the LF pups on days 7 and 29 of lactation (Figure 2). However, there was no significant different ($p>0.05$) for the body weight between LF and MF. The pups of HF had significantly higher ($p<0.05$) weight gain than those of LF and MF pups (weight gain for LF, MF and HF pups were 67.22 g, 68.76 g and 78.31 g, respectively).

The data presented in Table 2 summarizes the weekly feed intake of different treatment groups of dams. During pregnancy and lactation, weekly feed intake increased progressively for all the rats. Clear differences ($p<0.05$) in the feed intake were observed with the highest feed consumption for HF dams and lower for the LF and MF dams during pregnancy. One week before weaning, dams from HF had a higher ($p<0.05$) feed intake than the other groups of rats. Table 3 shows the results of the milk composition of dams during lactation. Milk fat was significantly higher ($p<0.05$) for HF rats than that of LF rats throughout the lactation. There were no differences ($p>0.05$) between HF and MF, and LF and MF dams. The milk protein concentrations were not significantly different ($p>0.05$) among the treatment groups. Analysis of the composition of VLDL obtained from dams throughout their pregnancy showed a progressive increase in the TG concentration measured (Figure 3, expressed as µg/ml of plasma) in the 3 weeks prior to parturition. After parturition, the VLDL-TG concentrations decreased progressively for all the treatment groups. The VLDL-TG concentrations were significantly higher ($p<0.05$) for HF rats than that of LF rats. However, no difference was observed ($p>0.05$) between LF and MF rats. In contrast, VLDL-protein concentrations (Figure 4) varied very little among the treatment groups throughout the pregnancy and lactation. However, the VLDL-protein concentrations increased for all the dams from different treatment groups during the first week of lactation. The VLDL-protein concentration of HF rats was significantly higher ($p<0.05$) than that of LF rats.

The greater feed intake observed in rats fed HF diet may be associated with a better palatability of the diet than other diets (MF and LF). The body weight of dams from different treatment groups showed a similar increment of weight gain. The results show similar trends to those reported elsewhere for rats (Rolls *et al.*, 1984; Del Prado *et al.*, 1997) and for other species (Montelongo *et al.*, 1992). This is important for the pregnant dams to prepare themselves for the lactating period. It has been shown that feed intake of dams is correlated with the growth of their pups (Rolls *et al.*, 1984). The growth of HF-pups was better than those of LF and MF pups. This faster growth may be associated with a better quality of milk produced from their dams. This explanation could be supported by the results of higher milk fat concentration in HF milk compared to the LF and MF milk. Brandorff (1980) reported that a high fat diet changes the fatty acid composition of rat milk by increasing the long-chain fatty acid content at the expense of medium chain fatty acids. The medium fatty acids are more readily utilised for energy and less deposited into adipose tissue triacylglycerols (Bray *et al.*, 1980). The findings of improvement in the growth of pups from fats fed a high fat diet are inconsistent (Grigor and Warren, 1980; Green *et al.*, 1981; Rolls *et al.*, 1984; Del Prado *et al.*, 1997). Grigor and Warren (1980) fed lactating rats a diet containing peanut oil (a mixture of oleic and linoleic acids). That diet resulted a better growth rate in pups from dams fed a diet containing peanut oil than control rats fed with a commercial diet. In contrast, pups from lactating dams fed a diet containing coconut oil (490g lauric acid/kg oil) had a similar growth rate with the pups from dams fed with a commercial diet. Experiments in lactating dams fed a fat added diet showed a better weight gain of the litter relative to that of controls fed a commercial diet only (Green *et al.*, 1981). The inconsistent results among these studies might be due to differences in fat types used and only one concentration was used in a specific study. This resulted in the effects of fat in the diets of dams might not be seen clearly. However, in the present study only palm oil and three different concentrations were used. The LF dams lost more weight than those of MF and HF dams during lactation. These results indicate LF dams had a more deficit energy balance, which could be explained by the limited energy intake and high energy utilization in milk production (Del Prado *et al.*, 1997). The findings of the milk fat concentrations response to high fat diet. The results herein suggest the composition of milk could be modified by dietary fat. Del Prado and co-workers (1997) showed that dams fed on a high lipid diet during pregnancy and lactation had a higher milk lipid concentration and daily milk volume and lipid production. In a pig study by Shurson *et al.* (1986), addition of 10% dried fat to the diets of sow during the late gestation and lactation periods resulted in heavier litters and heavier average piglets weights at 21 days compared to control pigs. There was 13% increased in estimated milk yield and the higher fat concentration of milk consumed by the pigs nursing sow supplemented fat diet.

The composition of TG in VLDL increased progressively prior to parturition, and reducing to the values obtained prior to mating. The results show similar rends to those reported elsewhere for human (Herrera *et al.*, 1987; Montelongo *et al.*, 1992; Knopp *et al.*, 1986) and for pigs (Reese *et al.*, 1984; Wright *et al.*, 1995). In mammals, it has been shown that adipose triacylglycerol is mobilised during late pregnancy; the liberated fatty acids are incorporated into very low density lipoprotein by the liver and secreted into the blood stream (Herrera *et al.*, 1992; Montelongo *et al.*, 1992; Wright *et al.*, 1995). The results in this study corroborated those findings by showing hypertriacylglycerolaemia in late-pregnant rats. However, the responses were greater in those rats fed with HF diet than those of LF and MF diets. The measurement of VLDL-protein indicates the number of VLDL particles in the plasma (Wright *et al.*, 1995) due to the presence of apo-B which is the largest of the apolipoprotein and is the major protein constituent of the lipoprotein (Davis, 1991). The concentration of VLDL-protein increased in the plasma for all the treatment groups one week after parturition. The results are therefore an indication that plasma contains higher number of VLDL during the first week of lactation. During lactation, there was a corresponding fall in VLDL-TG and a rise in the plasma concentration of VLDL-protein. Those results suggest that increase number of VLDL in the plasma in response to the increased of requirement for the milk fat synthesis by the mammary gland. The HF dams showed a better response to the dietary fat than that of LF and MF dams. The relationship between higher fat concentrations in the milk of rats fed HF diet is congruent with the high body weight of pups. Body weight of pups before weaning depends solely on the milk produced from the dams. Therefore, we can conclude that the higher milk fat production could be achieved by greater extraction of lipid from plasma VLDL through provision of high fat diet during pregnancy and lactation.

Conclusions

In conclusion, the rats fed with high fat diet during pregnancy and lactation develop higher VLDL-TG in the plasma during late gestation and higher VLDL-protein immediately after parturition and produce higher concentration of fat in the milk. These results imply the important roles of dietary fat in altering milk quality through greater movement of plasma lipids, particularly VLDL into mammary cells. Furthermore, all these improve the growth of pups.

Benefits from the study

A better dietary fat will be identified that will result in production of high quality and quantity of milk. The type of milk produced will have profound effects on survival rate and growth rate in neonate

Patent(s), if applicable :

Nil

Stage of Commercialization, if applicable :

Nil

Project Publications in Refereed Journals

1. Loh, T.C., H.L Foo, A.W. Zurina and B.K.Tan. (2002) Effects of feeding fat during pregnancy and lactation on growth performance, milk compositions and very low density lipoprotein compositions in rats. *Malaysian Journal of Nutrition*. 8(2): 125-135.

2. Loh, T.C., H.L. Foo, B.K. Tan and Jelan, Z.A. (2002) Effects of palm kernel cake on growth performance and blood lipids in rats. *Asian-Australasian Journal of Animal Science*. 15 (8): 1165-1169.

3. Loh, T.C., Y.F. Phang and H.L. Foo (2002) Comparison of the effects of supplemental oil on performance and blood lipids in rats. *Malaysian Journal of Animal Science* (In press)

4. Loh, T.C., A.W. Zurina, H.L. Foo and B.K. Tan (2003) Maternal fat intake during pregnancy and lactation alters milk compositions and very low density lipoprotein compositions in rats. *Agro-Search (In press)*

Project Publications in Conference Proceedings

1. Loh, T.C., H.L. Foo, A.W. Zurina and B.K. Tan (2002) Effects of feeding fat during pregnancy and lactation on very low density lipoprotein compositions in rats. 14th Veterinary Association Malaysia/12th Federation of Asian Veterinary Association Congress. pp186.

2. Loh, T.C., Y.F. Phang and H.L. Foo (2002) Comparison of the effects of supplemental oil on blood lipids in rats. 14th Veterinary Association Malaysia/12th Federation of Asian Veterinary Association Congress. pp176.

Graduate Research

Name of Graduate	Research Topic	Field of Expertise	Degree Awarded	Graduation Year
Zurina AW	Effects of Feeding Fat During Pregnancy and Lactation on Growth Performance and Milk Compositions in Rats	Animal biochemistry	BSc	2000
Nur Shukriyah	Effects of Feeding Fat During Pregnancy and Lactation on Growth Performance, Milk Compositions and Very Low Density Lipoprotein Compositions in Rats	Animal biochemistry	MS	End of year 2003

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