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Maternal Hypertriglyceridemia during Late Pregnancy Does Not Affect the Increase in Circulating Triglycerides Caused by the Long-Term Consumption of a Sucrose-Rich Diet by Rats[1]

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ABSTRACT Feeding a sucrose-rich diet (SRD) during pregnancy enhances maternal hypertriglyceridemia. The goal of this study was to investigate whether this effect is modified when pregnancy is initiated in rats at different times during feeding of a SRD (63 g sucrose/100 g). One group of rats was fed the SRD; another group received the same diet except that the sucrose was replaced by an equal amount of cornstarch. At different times during the feeding of the diets, i.e., 5, 45 or 90 d, half of the rats were mated; after serial tail blood collections, rats were studied at d 20 of pregnancy. Virgin rats fed the same diets were always studied in parallel. Plasma triglycerides increased progressively in virgin rats fed the SRD from d 1 to 35, declined thereafter up to d 50, increased again to attain the highest level at d 65–70, partially declined at d 100 and increased again at d 110. During late pregnancy, rats fed the control diet (CD) always had greater plasma triglyceride concentrations than virgin rats, whereas triglyceride levels did not differ between pregnant and virgin rats fed the SRD. These intergroup differences were similar to those seen for plasma VLDL-triglycerides. The liver triglyceride concentration in virgin rats fed the SRD was always significantly higher than that of rats fed the CD, whereas it did not differ in pregnant rats fed the SRD for either 25 or 65 d from those fed the CD. However, in those fed the SRD for 110 d, values were higher than in either pregnant or virgin rats fed the CD. We propose that the known capability of the liver to enhance triglyceride secretion during pregnancy protects dams from developing a fatty liver when fed a SRD for short periods of time, although not for long-term treatments. J. Nutr. 130: 2883–2888, 2000.

KEY WORDS: • *sucrose-rich diet* • *pregnancy* • *hypertriglyceridemia* • *VLDL* • *rats*

Prolonged fructose or sucrose feeding increases fasting triglyceride concentrations in healthy (MacDonald 1966, Swanson et al. 1992) or hyperlipidemic subjects (Antar et al. 1970), and the inclusion of sucrose in a lipid-rich meal amplifies the postprandial triglyceridemia (Grant et al. 1994); the effect is likely a consequence of the fructose moiety of the sucrose (Cohen and Schall 1988, Nikkila and Pelkonen 1966, Swanson et al. 1992). In normal rats, a sucrose- or a fructose-rich diet also induces hypertriglyceridemia and insulin resistance (Bernal et al. 1989, Gutman et al. 1987, Lombardo et al. 1996, Zavaroni et al. 1982). The factors responsible for the hypertriglyceridemia are increased hepatic VLDL synthesis and secretion (Sleder et al. 1980, Zavaroni et al. 1982) and impaired peripheral clearance due to both increased insulin resistance (Zavaroni et al. 1980) and decreased adipose tissue lipoprotein lipase activity (Bernal et al. 1989, Soria et al. 1996).

Although the mechanism is not yet completely understood, in male rats, the increase in plasma triglyceride levels due to high sucrose intake is multiphasic, depending on the period of treatment. These levels increase progressively until d 22–25 of treatment, then decline up to normal values at 45–50 d and rise again to attain the highest values at 75–90 d (Gutman et al. 1987).

Both hypertriglyceridemia and insulin resistance occur during pregnancy in humans (Alvarez et al. 1996, Freinkel 1980, Montelongo et al. 1992) and rats (Knopp et al. 1970, Martin-Hidalgo et al. 1994, Ramirez et al. 1983). Gestational hypertriglyceridemia seems to be the result of enhanced production of triglycerides by the liver (Wasfi et al. 1980) and decreased clearance of circulating triglycerides, which is a consequence of reduced lipoprotein lipase activity in adipose tissue (Herrera et al. 1988, Martin-Hidalgo et al. 1994). Although one would expect that these changes would be greatly enhanced when a sucrose-rich diet (SRD)[3] is fed during pregnancy, we found previously that the hypertriglyceridemic responsiveness to this diet is similar in virgin and pregnant rats when fed for 20 d (Soria et al. 1996). However, a SRD during pregnancy in rats has been reported to have teratogenic effects (Ornoy and Cohen 1980) or to reduce fetal or newborn weights (Jen et al.

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[3] Abbreviations used: CD, control diet; IOD, integrated optical density; SRD, sucrose-rich diet.

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1991, Soria et al. 1996), although other authors report no effect on this variable (Oliveros et al. 1995).

Although the response to a SRD may differ depending on the time of treatment, this time effect has not been studied previously in female rats, nor has the nature of the variation in gestational hypertriglyceridemia and pregnancy outcome been examined when established at different times after SRD intake. Thus, the goal of the present work was to compare the long-term effects of SRD on plasma triglycerides in pregnant and virgin female rats.

MATERIALS AND METHODS

Animals. Female Sprague-Dawley rats from our animal quarters were initially fed a nonpurified diet (B&K Universal, Barcelona, Spain) and housed under controlled light and temperature conditions (12-h light:dark cycle; 22–23°C). The experimental protocol was approved by the Animal Research Committee of the University San Pablo-CEU in Madrid, Spain. Rats weighing either 160–170 g or 140–150 g (9 and 7 wk old, respectively) were divided into two groups as follows: *1*) experimental, in which rats were fed a purified sucrose-rich diet (63 g sucrose/100g; SRD); and *2*) control, in which rats were fed the same diet except that the sucrose was replaced with cornstarch (63 g/100g; CD). The diets were based on the AIN-76A diet; its composition has been reported previously (Soria et al. 1996). Both diets were isocaloric (15.28 kJ/g) and rats had free access to food and tap water.

Half of the rats (initial weight 160–170 g) from each group were mated with males of the same strain after 5 d of consuming the diets; rats initially weighing 140–150 g were mated after 45 or 90 d of consuming the diets. The day spermatozoids appeared in vaginal smears was considered d 0 of gestation. Rats were housed in collective cages (n = 4/cage). Daily food intake was not measured directly and was estimated only roughly because a considerable loss of food was detected. However, there were no apparent differences in food intake between rats fed SRD and CD (data not shown).

Pregnant and virgin rats were always studied in parallel. On different days of the experiment, blood was collected from the tip of the tail into heparinized receptacles. On d 25, 65 or 110 of feeding, the SRD or the CD, which always corresponded to d 20 of pregnancy in the case of pregnant rats, rats were decapitated and trunk blood was collected into ice-chilled tubes containing 1g/L Na_2-EDTA. The two uterine horns were dissected immediately to obtain the whole conceptus and fetal weights. Livers were quickly removed and placed into liquid nitrogen before freezing at −80°C until analysis.

Analytical methods. Plasma was separated by centrifugation at 1500 × g for 15 min at 4°C. Plasma samples from tail blood were kept frozen until processed, but plasma from trunk blood was subjected immediately to sequential ultracentrifugation in a Beckman TL-100 ultracentrifuge (Beckman Instruments España, Madrid, Spain) with a Beckman TLA 100.2 rotor. VLDL were separated at 224,000 × g for 3 h at d = 1.006 kg/L. Supernatants were recovered by tube slicing; after appropriate dilution, triglycerides were determined by a whole enzymatic method with colorimetric determination, using a commercial kit (#B-7648, Meranini Diagnostic, Florence, Italy). Triglyceride concentration was also determined in plasma using the same commercial kit.

Portions of frozen liver were extracted with chloroform/methanol (2:1) (Folch et al. 1957). Triglycerides were quantified after image analysis and separation by one-dimensional TLC (Ruiz and Ochoa 1997) using the G5–700 BIOIMAGE TLC scanner of Bio-Rad (Hercules, CA). Spots were quantified as integrated optical densities (IOD) against an internal standard of cholesteryl formate, which had been included in every application. Calibration curves were constructed by plotting the IOD of triglyceride standards, corrected by the IOD of cholesteryl formiate, vs. the amount of lipid loaded, and were drawn from second-order least-square regression equations.

Statistics. Data are expressed as means ± SEM. Data were log transformed because it was necessary to achieve equal variance among means. Statistical analysis of data was performed by one-way ANOVA followed by Tukey's test to establish differences among the four groups in rats treated for 25, 65 or 110 d. Two-way ANOVA was performed to test the main and interactive effects of diet and pregnancy on plasma triglycerides. Three-way ANOVA was also performed to test the main and interactive effects of diet, pregnancy and time of treatment, at the end of each experiment. Differences between two groups were analyzed by the Student's t test. All statistical analyses were performed using a computer software package (Systat Version 5.03, Wilkinson, Evanston, Il).

RESULTS

Final body weight of rats fed SRD for either 25 or 65 d did not differ from that of rats fed the CD when studied under either virgin or d 20 of pregnancy conditions (**Table 1**). However, at 110 d of SRD intake, virgin rats had the same body weight as those fed the CD, whereas pregnant rats had a higher body weight than those fed the CD. This difference corresponded mainly with the net maternal weight because fetal body weight did not differ between pregnant rats fed either the CD or SRD (Table 1); however, maternal body weight, free of conceptus, in rats fed the SRD for 110 d was significantly higher (447 ± 6 g) than in those fed the CD (381 ± 19 g, $P < 0.01$). Feeding the SRD greatly affected liver weight, which was significantly higher in virgin rats fed this diet for 65 or 110 d than in those fed the CD, whereas pregnant rats fed CD always had a heavier liver than virgin rats fed the CD. Feeding the SRD for 25 or 65 d did not further modify this variable. Liver was heavier, however, in pregnant rats fed the SRD for 110 d than in those fed the CD for the same time period (Table 1). A three-way ANOVA was performed to investigate whether the effects of diet, time of pregnancy on final body and liver weight were interactive; the analysis showed that their respective main effects on either variable were significant, except for that of diet on final body weight (Table 1).

When rats were studied for 25 d, at d 5 or 15 of feeding the SRD, plasma triglycerides were significantly higher than in rats fed the CD, and values did not differ between virgin and pregnant rats fed either diet (**Fig. 1**). Between d 15 and 25 of the experiment, rats fed the SRD showed a further increase in plasma triglycerides, which was similar in virgin and pregnant rats. In rats fed the CD, however, this increase was seen only in pregnant rats (Fig. 1). Thus, at d 25 of feeding the diets, which corresponded to d 20 of pregnancy, plasma triglycerides did not differ in virgin rats fed the SRD and pregnant rats fed either the SRD or CD; concentrations were always higher than those found in virgin rats fed the CD, because the interaction of diet and pregnancy was significant (see Fig. 1 legend).

Feeding virgin rats the SRD for up to 65 d produced a biphasic change in plasma triglycerides (**Fig. 2**), as shown by a progressive rise that lasted up to d 35, followed by a decline to d 45; at that point, concentrations did not differ from those of virgin rats fed CD. This was followed by a new rise up to the d 65. When rats were mated at d 45 of treatment, pregnant rats fed the CD developed hypertriglyceridemia compared with virgin rats fed the same diet, and this change was similar to that seen in pregnant or virgin rats consuming the SRD during the same period (Fig. 2). In fact, at d 65 of consumption of the SRD, plasma triglyceride levels did not differ significantly between virgin rats fed the SRD and pregnant rats fed either the SRD or CD, and values in these three groups were higher than those in virgin rats fed the CD (Fig. 2). Although the effect of diet or pregnancy appeared significant, this was not the case when the interactions of the two factors were considered (see Fig. 2 legend).

When virgin rats were fed the SRD for 110 d, a second

TABLE 1

Initial and final body weights and liver weight in pregnant (P) and virgin (V) rats fed a sucrose-rich diet (SRD) or control diet (CD) for 25, 65 or 110 d, and fetal body weights (d 20 of intrauterine life)[1]

Diet, *d*	*n*	Initial body weight	Final body weight	Average fetal body weight	Liver weight
			g		
d 25					
P, CD	14	167.0 ± 3.4	344 ± 6[a]	4.2 ± 0.1	14.2 ± 0.4[a]
P, SRD	12	170.4 ± 3.4	342 ± 5[a]	4.3 ± 0.2	13.9 ± 0.6[a]
V, CD	8	172.1 ± 4.6	236 ± 4[b]		9.4 ± 0.4[b]
V, SRD	10	170.6 ± 3.9	238 ± 6[b]		10.9 ± 0.5[b]
d 65					
P, CD	6	156.3 ± 5.1	441 ± 11[a]	4.2 ± 0.2	13.9 ± 0.9[a]
P, SRD	6	156.6 ± 3.6	427 ± 7[a]	4.3 ± 0.1	14.9 ± 0.5[a]
V, CD	11	151.3 ± 3.4	311 ± 7[b]		8.6 ± 0.3[c]
V, SRD	9	159.6 ± 2.2	323 ± 8[b]		10.5 ± 0.5[b]
d 110					
P, CD	6	155.5 ± 2.6	442 ± 19[b]	4.4 ± 0.1	13.8 ± 1.0[b]
P, SRD	6	169.9 ± 4.7	520 ± 12[a]	4.5 ± 0.2	19.4 ± 0.8[a]
V, CD	8	161.1 ± 1.8	327 ± 13[c]		10.3 ± 0.4[c]
V, SRD	8	166.2 ± 2.5	359 ± 11[c]		12.7 ± 0.5[b]
Days of treatment				2 × 2 × 3 ANOVA[2]	
				probabilities of F ratio	
Diet			0.349		0.006
Pregnancy			<0.001		<0.001
Time			<0.001		0.02
Diet × Pregnancy			0.602		0.369
Diet × Time			0.127		0.023
Time × Pregnancy			0.046		0.2
Diet × Time × Pregnancy			0.029		0.008

[1] Values are expressed as means ± SEM. Tukey's test was used to determine differences between groups after ANOVA. Different superscripts in a row indicate significant differences ($P < 0.05$) among the four groups at the same day of treatment, 25, 65 or 110 d.

[2] ANOVA: Three-way ANOVA was performed to test the main and interactive effects of the three factors: diet, pregnancy and time of treatment (25, 65 or 110 d).

decline in plasma triglycerides occurred from d 70 to 100 when concentrations were significantly lower ($P < 0.01$, d 70 vs. 100); a second rise followed to d 110 ($P < 0.05$, d 100 vs. 110), when concentrations were higher than at any previously studied times (**Fig. 3**). Pregnancy in rats fed the CD led to the expected increase in plasma triglycerides, whereas rats mated at d 90 of consuming the SRD showed a decline in plasma

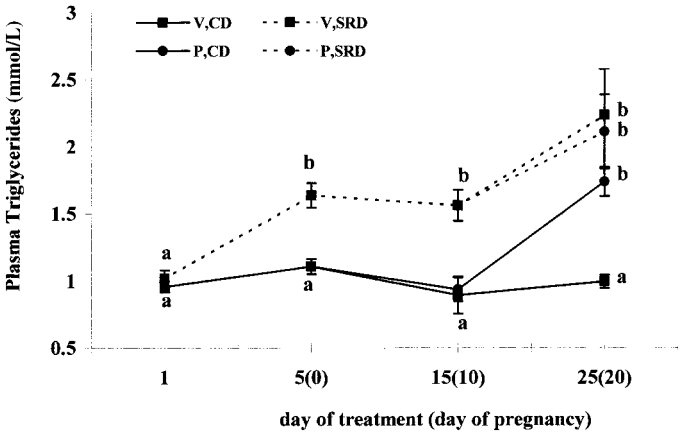

FIGURE 1 Plasma triglycerides in virgin (V) or pregnant (P) rats fed a sucrose-rich (SRD) or control (CD) diet for 25 d. Values are means ± SEM, $n = 8–14$. Statistical analysis of data was performed by one-way ANOVA followed by Tukey's test. Different letters indicate significant differences between groups ($P < 0.05$) at each sampling time. *P*-values estimated by two-way ANOVA were 0.003 for diet (D), 0.271 for pregnancy (P) and 0.032 for D × P.

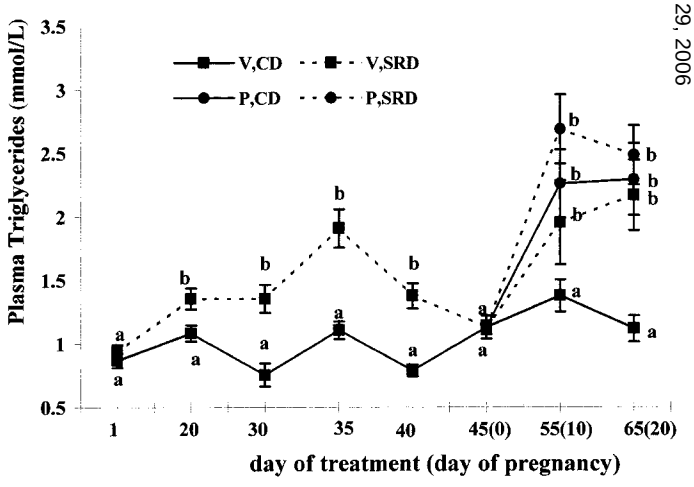

FIGURE 2 Plasma triglycerides in virgin (V) or pregnant (P) rats fed a sucrose-rich (SRD) or control (CD) diet for 65 d. Values are means ± SEM, $n = 6–11$. Statistical analysis of data was performed by one-way ANOVA followed by Tukey's test. Different letters indicate significant differences between groups ($P < 0.05$) at each sampling time. *P*-values estimated by two-way ANOVA were 0.004 for diet (D), 0.007 for pregnancy (P) and 0.075 for D × P.

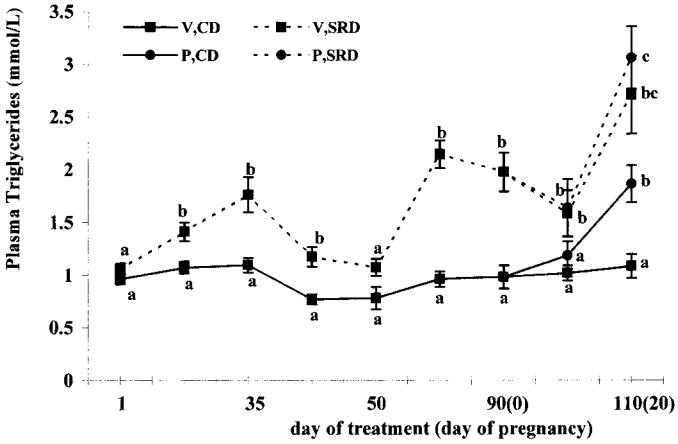

FIGURE 3 Plasma triglycerides in virgin (V) or pregnant (P) rats fed a sucrose-rich (SRD) or control (CD) diet for 110 d. Values are means ± SEM, $n = 6–8$. Statistical analysis of data was performed by one-way ANOVA followed by Tukey's test. Different letters indicate significant differences between groups ($P < 0.05$) at each sampling time. *P*-values estimated by two-way ANOVA were <0.001 for diet (D), 0.132 for pregnancy (P) and 0.373 for D × P.

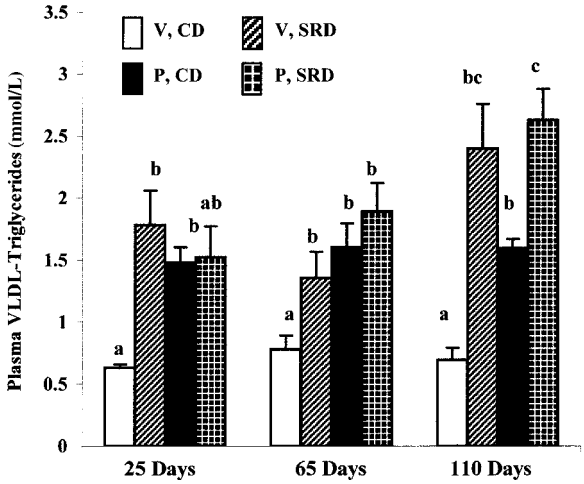

FIGURE 4 Plasma VLDL-triglycerides in virgin (V) and pregnant (P; d 20) rats fed a sucrose-rich (SRD) or control (CD) diet for 25, 65 or 110 d. Values are means ± SEM, $n = 6–14$. Statistical analysis of data was performed by one-way ANOVA followed by Tukey's test. Different letters indicate significant differences between groups ($P < 0.05$) at each sampling time. *P*-values estimated by three-way ANOVA were <0.001 for diet (D), 0.009 for pregnancy (P), 0.085 for time of treatment (T), 0.017 for D × P, 0.463 for T × P and 0.501 for D × P × T.

triglycerides at d 10 of pregnancy (d 100 of consuming the SRD). This was followed by a later rise, similar to the differences seen at the same time points in virgin rats fed the SRD (Fig. 3). Plasma triglyceride levels at 110 experimental days were not different in virgin and 20 d pregnant rats fed the SRD, although values in the latter group were higher than those in pregnant rats fed the CD; values in both groups were higher than those in virgin rats fed the CD (Fig. 3). In this experiment, the effect of diet was significant, whereas this was not the case for the effect of pregnancy nor for the diet × pregnancy interaction (see Fig. 3 legend).

To investigate whether the effects of time of feeding the corresponding diet, type of diet and pregnancy on plasma triglycerides were interactive, a three-way ANOVA was performed with data from rats fed the corresponding experimental diet for 25, 65 or 100 d (**Table 2**). The ANOVA showed that the main effects of diet and pregnancy on plasma triglycerides were significant, whereas time interaction became significant only when dietary treatment was taken into account (Table 2).

Plasma VLDL-triglycerides were measured in all groups at the end of the treatments. Values did not differ significantly in virgin rats fed the CD for 25, 65 or 110 d; however, they were enhanced in virgin rats fed the SRD for the same time periods (**Fig. 4**). Pregnant rats fed the CD had plasma VLDL-triglycerides that were always higher than those of virgin rats fed the same diet, independently of the time of treatment (Fig. 4). However, unlike what occurred in virgin rats, and with the exception of pregnant rats fed the SRD for 110 d in which VLDL-triglycerides were higher than in those fed the CD for the same time, no significant difference was found in this variable between pregnant rats fed the SRD and CD for 25 or 65 d, and these concentrations were similar to those in virgin rats fed the SRD for the same times (Fig. 4). Although both diet and pregnancy and these two factors together significantly enhanced plasma VLDL-triglycerides, the time factor was not reach significant, nor was the interaction of time, diet and pregnancy (see Fig. 4 legend).

Compared with rats fed the CD, total liver triglyceride concentration was higher in virgin rats fed the SRD for 25, 65 or 110 d; the difference was particularly striking in those rats fed the diets for 110 d (**Fig. 5**). In pregnant rats fed the CD, liver triglyceride concentration was not different from that of virgin rats fed the same diet. Pregnant rats fed SRD for 25 or 65 d had liver triglycerides that did not differ from those fed CD; levels were even lower than those in virgin rats fed the SRD for the same period of time (Fig. 5). However, this was not the case when rats were studied after 110 d of consuming the SRD; in that case, liver triglyceride concentration in pregnant rats was higher than that in other pregnant rats and not significantly different from virgin rats fed the SRD for 110 d (Fig. 5). The three-way ANOVA of total liver triglycerides showed that there was a significant interaction between diet and time, although this was not the case when pregnancy was considered (legend for Fig. 5).

TABLE 2

Three-way ANOVA of plasma triglycerides after 25, 65 or 110 d (Time) of feeding a sucrose-rich or control diet (Diet) in virgin and pregnant rats (Pregnancy) or combination thereof

Factors	Plasma triglycerides
	probabilities of F ratio
Diet (D)	<0.001
Pregnancy (P)	0.008
Time (T)	0.362
D × P	0.021
D × T	0.042
P × T	0.381
D × P × T	0.484

DISCUSSION

Despite the hypertriglyceridemia occurring consistently during late pregnancy in rats, pregnancy does not modify the hypertriglyceridemic effect of feeding a SRD even for a long period of time (up to 110 d). In fact, although an increase in

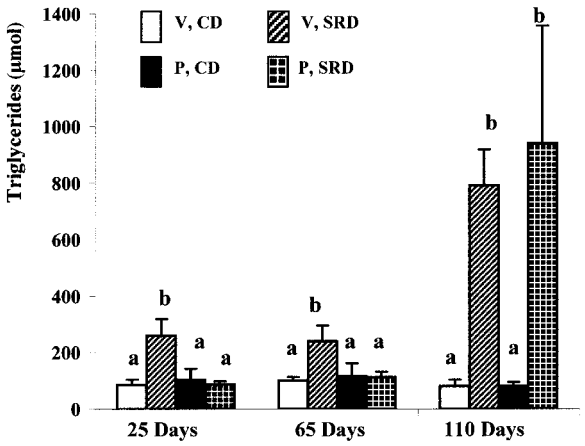

FIGURE 5 Liver triglyceride concentration in virgin (V) and pregnant (P; d 20) rats fed a sucrose-rich (SRD) or control (CD) diet for 25, 65 or 110 d. Values are means ± SEM, $n = 6–14$. Statistical analysis of data was performed by one-way ANOVA followed by Tukey's test. Different letters indicate significant differences between groups ($P < 0.05$) at each sampling time. *P*-values estimated by three-way ANOVA were <0.001 for diet (D), 0.634 for pregnancy (P), <0.001 for time of treatment (T), <0.001 for D × T, 0.454 for D × P, 0.186 for T × P and 0.257 for D × P × T.

plasma triglycerides was always seen during late gestation in rats fed the CD, this effect disappeared when rats were fed a SRD, and virgin and pregnant rats fed the SRD had the same concentrations. This is the first report showing the long-term multiphasic effect of feeding the SRD to female rats on plasma triglycerides as well as the effects of pregnancy. A previous report from our laboratory (Soria et al. 1996) showed that the proportional hypertriglyceridemic effect of feeding a SRD for 25 d is similar in virgin and pregnant rats, and Oliveros et al. (1995) showed that 19 d of gestation and feeding a SRD in rats does not modify plasma triglyceride levels compared with those seen in pregnant rats fed an isocaloric dextrin diet for the same period of time. Our rats were killed at a time of treatment, which coincided with the highest hypertriglyceridemia response to SRD, i.e., 25, 65 and 110 d, showing that such change corresponded mainly to an enhancement in plasma VLDL-triglycerides.

The development of hypertriglyceridemia during the induction period of feeding a SRD (2–5 wk) in male rats appeared to be the combined effect of increased liver VLDL secretion and decreased clearance in the presence of insulin resistance (Bernal et al. 1989, Gutman et al. 1987). These changes coincided with those taking place during pregnancy under normal conditions (Martín et al. 1986, Soria et al. 1996). Because present findings showed that hypertriglyceridemia has already developed after 5 d of feeding SRD in nonpregnant rats, it is possible that liver VLDL secretion capability was stimulated, whereas extrahepatic clearance was already decreased in nonpregnant rats after this short time of feeding the SRD, leaving no possibility of additional changes when pregnancy was initiated. Liver triglyceride secretion rate would also depend on triglyceride availability, and it seems that due to the enhanced ability to secrete newly formed triglycerides in pregnant rats fed the SRD for 25 d (Soria et al. 1996), the liver does not accumulate triglycerides as in virgin rats. This would limit the possibility for an additional increment in liver triglyceride secretion when rats fed the SRD are studied during pregnancy, thus avoiding an additional increase in plasma triglyceride levels in pregnant rats fed the SRD over those in rats fed the CD.

Consistent with previous studies conducted in male rats (Gutman et al. 1987, Schonfeld and Pfleger 1971), we found a spontaneous normalization of plasma triglyceride levels in the medium-term treatment with the SRD in female rats (40–50 d), which was followed by a recurrent period that was not modified when rats were subjected to pregnancy and studied at d 65 of consuming the same diet. This recurrent period also appears with a glucose intolerance and insulin resistance condition in nonpregnant rats (Gutman et al. 1987); here again, the metabolic conditions seem to mimic those normally found in pregnancy. Thus, it is not surprising that the hypertriglyceridemic responsiveness of pregnancy in control rats is similar to that seen in nonpregnant rats fed the SRD for this period of time; nevertheless, one would expect that these changes would be synergistically enhanced when the two conditions coincide. However, it was found here that not only does pregnancy not enhance the hypertriglyceridemic effect of the SRD but that pregnant rats fed the SRD for either 25 or 65 d had a lower liver triglyceride concentration than virgin rats. This difference is likely a consequence of the greater capability of the liver of pregnant rats to secrete triglycerides, as discussed above. In fact, this hypothesis agrees with the findings of previous reports showing unchanged or even decreased liver triglyceride concentrations in control rats during late pregnancy despite hypertriglyceridemia (Herrera et al. 1969 and 1988, Montes et al. 1978).

The difference in liver triglyceride concentration between pregnant and nonpregnant rats disappeared, however, when rats were studied at d 110 of consuming the SRD; at that time point, liver triglycerides had accumulated in pregnant as in virgin rats, and plasma VLDL triglycerides in SRD-fed rats in late pregnancy reached a higher level than in pregnant rats fed the CD. At this time, the net body weight increase of pregnant rats (free of conceptus) fed the SRD is greater than that in any other condition studied. Because we know that the increase in net maternal body weight during pregnancy corresponds mainly to fat (Herrera et al. 1988, López-Luna et al. 1986), such a change indicates that those rats had highly enhanced fat depots. Significant increases in body weight gain and food intake were seen previously in male rats fed the SRD for 30 wk, although not for shorter time periods (Lombardo et al. 1996). Because pregnancy itself causes hyperphagia, the increase in body weight found in our pregnant rats fed the SRD for 110 d may have been the result of an enhanced intake of sucrose; thus, they reached the threshold for fat accumulation earlier than nonpregnant rats fed the same diet.

The increase in plasma triglycerides in pregnant rats fed the SRD for 110 d to the level found in nonpregnant rats would indicate that liver triglyceride export capability can become saturated. A saturation of triglyceride output capability was reported previously in perfused livers or cultured hepatocytes of nonpregnant rats after consumption of the SRD for short (3 d to 3 wk) or long (15 wk) periods (Bernal et al. 1995, Boogaerts et al. 1984, Yamamoto et al. 1987), and any further uptake or synthesis of triglycerides would result in increased cellular storage. Thus, because we found that liver triglyceride accumulation occurred only in pregnant rats fed the SRD for 110 d but not for shorter period of times, whereas it was already present in nonpregnant rats at 25 d, it appears that the high capability of maternal liver to secrete triglycerides during pregnancy protects her from developing a fatty liver when fed a SRD for short periods of time.

In agreement with previous reports carried out for only 19 d (Oliveros et al. 1995), feeding a SRD for up to 110 d did not affect pregnancy outcome in the present study. This finding contrasts, however, with the decreased fetal weight reported

previously in pregnant rats fed SRD for 25 d (Soria et al. 1996). The reason for this different response is unknown, but it could reside in the strain because Wistar rats were used in that study, whereas Sprague-Dawley rats were used here. More experiments are required, however, to determine the precise reason(s) for this different response, which may well be secondary to differences in the sensitivity of the response to sucrose in other metabolic sites, including maternal insulin resistance. In any case, these findings show that the conditions of exaggerated maternal hypertriglyceridemia and liver triglyceride accumulation that are seen in pregnant rats fed the SRD for 110 d do not necessarily impair fetal growth; such protection could well be the result of the impermeability of the placenta for maternal circulating triglycerides (Herrera et al. 1998).

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