4 Results

4.1 General data

Four hundred-eighty cows were used in this study. Their age varied from 1, 5 to 10 years (4, 5 ±1,6) and body weight was between 357 and 802 kg (546, 5±84, 4). These cows were admitted to the clinic of ruminants, faculty of veterinary medicine, free university. They were randomly chosen for this investigation. Dairy cows of this study were in different lactation states. Clinical examination of cows on the day of admission to the clinic revealed that 345 (71.9%) of them suffered from left displacement of the abomasum (LDA), 40 cows (8.4 %) had a right displacement of the abomasum (RDA) and 95 cows (19.8 %) had other diseases like pneumonia, claws affection, mastitis and metabolic disorder. Moreover, approximately one third of the examined animals had endometritis.

4.2 Liver biopsy

4.2.1 Technique of liver biopsy

Liver biopsies were performed on 480 dairy cows in order to diagnose fatty liver. Biopsies were performed on the day of admission or one day after admission. The biopsies were performed on each animal under local anesthesia to avoid pain produced from insertion of the needle and to reduce the chance of accidental puncture of other organs. Liver biopsies were obtained from each cow by percutaneous needle biopsy „Berliner model" (picture 2) in the stall. The weight of a sample was approximately 0.1 to 0.2 g. The procedure is quick (with practice, about 20 samples/ hour). A single individual performed all biopsies in this study in the stall under light control by using a neck rope. The technique of the liver biopsy was used as routine examination under field conditions without measurable effect on milk production and general health condition.

Liver biopsy was applied on 480 cows and no adverse consequences from introduction of the needle into the animals were recorded except for one case where the pancreas was punctured of pancreas due to a false direction of the needle at the beginning of the work. Some troubles were faced in fatty cows due to a fatty mesentery and some liver biopsies did contain mesenteric fat.

4.2.2 Methods of fat content estimation

Fat content of biopsies was estimated by either the copper sulfate test, which depends on specific gravity or gravimetrically by fat extraction and weighing.

4.2.2.1 Copper sulfate test

Liver lipid concentration and specific gravity are closely related to each other. The buoyancy of 480 liver specimens, with a broad range of lipid content, were observed in copper sulfate solutions with different specific gravity (1000, 1010, 1100). Each sample floated or sank in accordance with its lipid content as shown in picture 3. The number of animals in each fat content masses are promted in table 2.

IAbout 221 (46%) cows had a fat liver content between 0 and 15,5%. 165(34,4) of the investigated cows had a total fat content of livers between above 15,5% to 26%, while 74 cows (15, 4%) did show fat content between more than 26 to 33%. The rest of the cows which were 20 animals (4, 2%), had fat content of more than 33%.

4.2.2.2 Gravimetric method

The total lipid content of each sample was determined gravimetrically. It was observed that the homogenization of samples with tissue lysine buffer (ATL) achieved a high percentage of liver cells destruction and consequently resulted accurate estimation of total lipids in the liver samples. The different lipid contents and number of animals are tabulated in table 2.

There are no great differences in the number of animals in each total lipid groups of both the copper sulfate test and the gravimetric method. For 224 (46,7%) examined cows, the fat content varied from 0 to 15, 5% and 159 (33, 1%) cows had fat contents higher than 15,5 and 26 % fat in their livers. Moreover, for 78 (16, 3%) cows, the total fat content of livers ranged from more than 26% to 33 % and 19 (3, 9%) cows had fat contents higher than 33 %.

On the basis of the fat content of livers measured either by the copper sulfate test or gravimetrically, the livers were classified as normal liver when they contained fat up to 15, 5%, as mild fatty if they contained from >15, 5 to 26% fat, as moderate fatty liver with fat contents between >26% and 33% or as severe fatty when the fat content was higher than 33 %.

Table 2. Number of animals and liver fat content determined either by the copper sulfate or by the gravimetric method (n=480).

Fat content of liver (%)	Copper Sulfate Test		Gravimetric method	
	No of animals	Percentage	No of animals	Percentage
0 – 15,5 (normal)	221	46%	224	46,7%
>15,5 – 26 (mild)	165	34,4%	159	33,1%
>26 – 33 (moderate)	74	15,4%	78	16,3%
>33 (severe)	20	4,2%	19	3,9%
Total	480	100%	480	100%

4.2.2.3 Relationship between the results of the copper sulfate test and the gravimetric method

The comparison of the results of the copper sulfate and gravimetric methods for the estimation of total fat content of livers revealed a strong significant correlation (r=0.98) between the two methods as shows in figure 1.

The regression between both methods appears linear in all specific gravity ranges between 1000 and 1100 which confirms the accuracy of the copper sulfate method which therefore can be used as rapid field test for the estimation of total lipid contents of livers rather than using sophisticated methods for measurement.

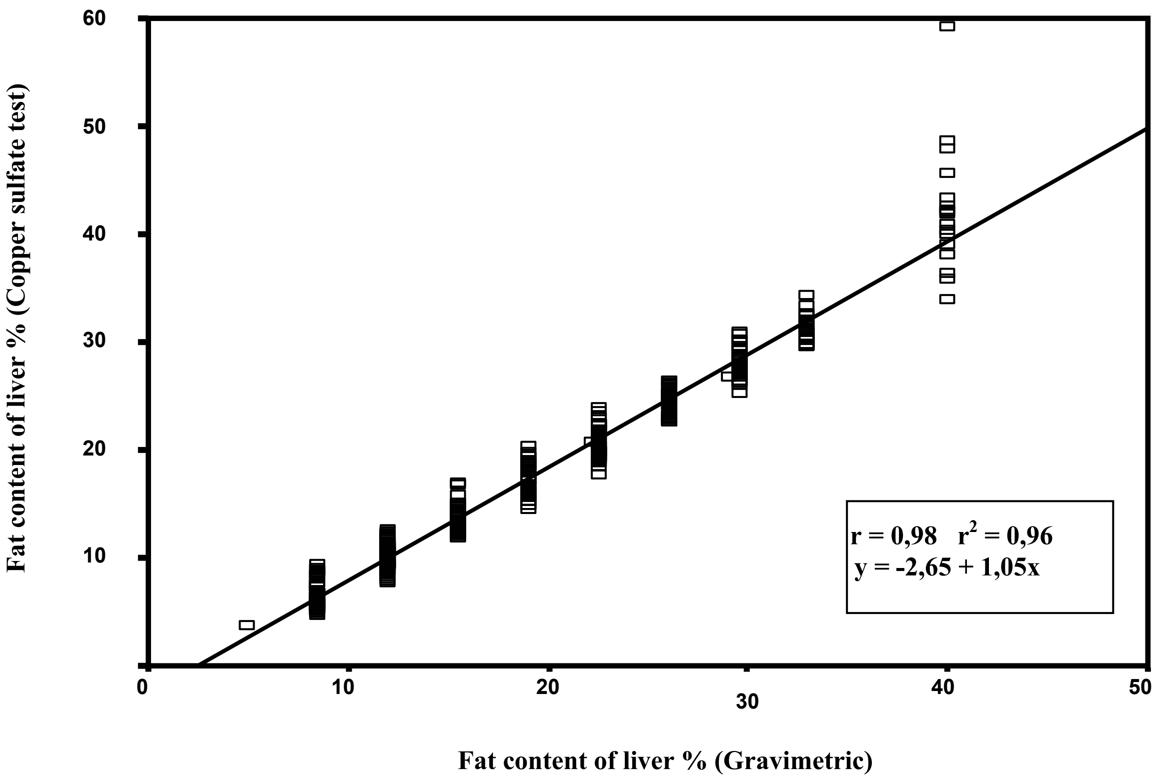


Figure 1. Correlation between gravimetric and copper sulfate methods (n=480)

4.2.3 Estimation of triglyceride content of liver

The hepatic triglyceride concentrations for each group of fatty livers are tabulated in table 3. Livers classified as normal livers when the triglyceride concentration varied from 0 to10 %, the number of cows in this group was 286 cows (59.6 %). Mild fatty livers contain triglyceride in range from more than 10% to 15%, this group did include 123 cows (25.6 %). Moderate hepatic lipidosis had hepatic triglyceride concentrations higher than the mild type. The triglyceride concentrations of this group was between more than 15 % and 20 % and involved 42 (8, 8%) cows. Severe fatty liver was characterized by increased triglyceride contents of more than 20 %, and 29 animals(6 %) were affected.

Table 3. Liver triglyceride contents and their related number of animals (n=480)

Triglyceride content (%)	No of animals	Percentage
0 – 10 (normal)	286	59.6 %
>10 – 15 (mild)	123	25.6 %
>15 – 20 (moderate)	42	8.8 %
>20 (severe)	29	6.0 %
Total	480	100 %

The correlation between total fat content of livers and mean liver triglyceride concentrations is shown in figure 2. The figure shows a highly significant positive correlation ($p<0, 01$) between parameters. The correlation coefficient was 0,94. in addition to that, there also was a highly significant positive correlation $p<0,01$ between fat content of livers and the triglyceride content of total fat content of liver. The respective correlation coefficient though was lower($r=0.76$) than the correlation between total liver triglycerides and total fat content of livers (Figure 3).

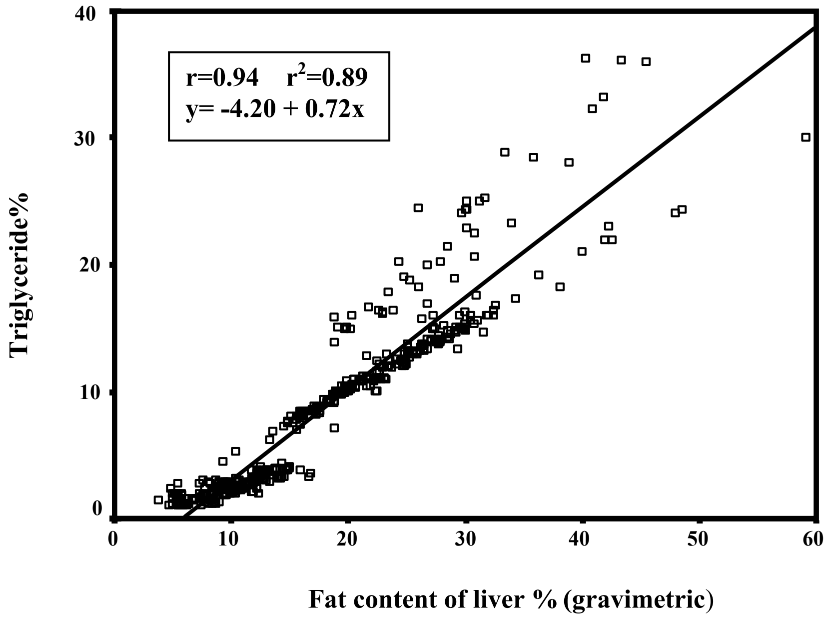


Figure 2. Correlation between fat content of livers and triglycerides (n=480)

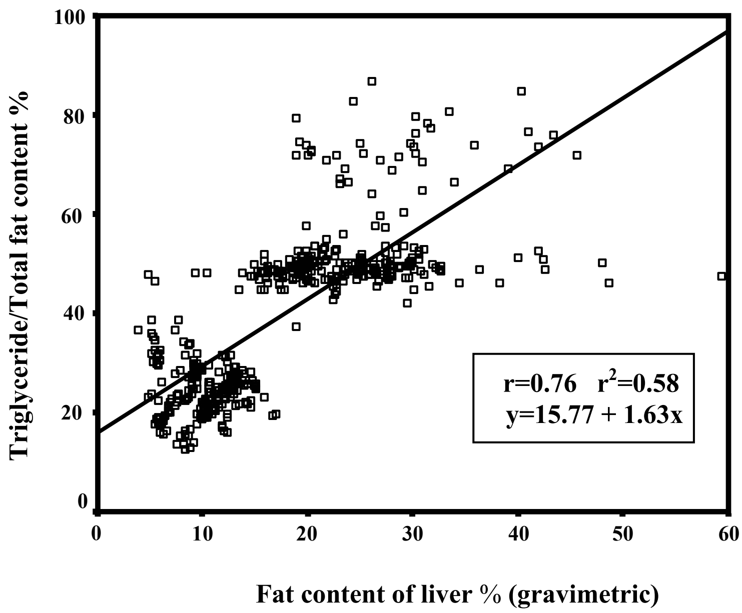


Figure 3. Correlation between fat content of liver (%) and triglyceride/fat content (%) (n=480)

4.3 Clinical signs of fatty liver

The mean values of temperature, heart rate and respiratory rate in different classes of fatty liver are in table 4. There exists a significant variation ($p<0.05$) in the mean values of rectal temperatures between the normal, mild and moderate fatty liver groups, while the severe fatty liver group did not different significantly. Moreover, the values of rectal temperature were within normal range except the cows that suffered from endometritis did show some increase in rectal temperature Heart rate and respiratory rate were not significantly changed between all groups except that the heart rate in severe fatty liver cows was significantly increased ($p<0.05$)..

Table 4. Mean values (±SE) of some clinical parameters in different liver condition groups (n=480)

Parameters	Normal liver (N=224)	Mild fatty liver (N=159)	Moderate fatty liver (N=78)	Severe fatty liver (N=19)
Temperature	38.5 ± 0.04 [a]	38.7 ± 0.05 [b]	38.2 ± 0.15 [b]	38.6 ± 0.6 [ab]
Heart rate	71.5 ± 0.73 [a]	70.6 ± 0.84 [a]	70.8 ± 1.5 [a]	78.3 ± 3.6 [b]
Respiratory rate	29.3 ± 0.6 [a]	29.1 ± 0.7 [a]	28.71 ± 1.3 [a]	28.5 ± 1.8 [a]

Same letters in the same row are non significant
Different letter are significant at $p<0.05$
N = number of animals

In cows with mild or moderate fatty liver, the clinical findings were much less severe and affected animals would recover within several days from fluid therapy treatment. Usually the conditions therefore passed without any detectable signs.

The cows affected with severe fatty liver were characterized by increased body weight and it was observed that a significant (p<0, 05) correlation between fat content and body weight did exist(r=0, 15). Affected cows were usually excessively fat, with a body condition score varyingfrom 4 to 5 or higher. Excessive quantities of subcutaneous fat were palpable over the flank, the shoulder areas and around the tail head.

Moreover, ruminal contraction was weak or absent in cows having severe fatty livers and the feaces were scanty and sometimes yellow in color, offensive and contained mucus. The mucus membranes in cases of severe fatty liver, especially the scleral mucus membranes and vaginal mucus membranes were icteric.

In addition to that, the cows find her suffered from depression, weakness, which lead to prolonged recumbancy and affected cows might have had difficulty to stand when they were coaxed to stand. Anorexia and severe ketosis not responding to the usual treatment were observed. There existed also a marked ketonuria which was approximately 2++ to 3+++. Animals became gradually weaker and progressive depression with a markedly decreases milk production did get in.

In extreme cases, central nervous system disturbance signs were exhibited, including staring gaze and holding the head high. Some cases detoriated and terminally became recumbent and comatose and didn't respond to treatment. Prognosis in these cases was poor and usually the affected cows died or were euthanized due to development of downer cow syndromes.

4.4 Relationship between fatty liver and different diseases

As shown in table 5, the majority of investigated cows suffered from LDA, this group of cows consisted of 345 animals (71, 9 %). The second most frequent group consisted of the cows which suffering from different diseases like pneumonia, claws affection, mastitis and metabolic disorders, this group contained about 95 animals (19.8 %). The remaining cows, 40 animals (8, 3 %) suffered from RDA.

The relationship between different diseases conditions and fat contents of livers as shown in figure 4, revealed that there was a significant increase ($p<0.05$) in liver fat content in the group suffering from left abomasal displacement than in the other two disease groups. The cows with left abomasal displacement showed moderate to severe fatty liver infiltration while the other two groups had moderate to low fat contents of livers. Moreover, it was found that there was significant increase ($p<0.05$) in total fat content in the other disease group above the right displacement of abomasums.

In addition to that, the number of animals with endometritis in the different disease groups was recorded (table 5). It was found that a high prevalence of endometritis was found in the LDA group. 132(27,5) of the total of cows with LDA in this group (345) also had endometritis. In the other two diseases groups, only 28 animals of the total number of 95 animals had endometritis. The lowest prevalence of endometritis was recorded in RDA where only 7 (1, 5 %) of total 40 cows were affected.

Referring to the relationship between fat content of liver, different disease conditions and endometritis (figure 5) in each of above-mentioned groups, it was observed that the fat content of livers was significantly increased ($p<0.05$) in LDA cows either with endometritis or without. In addition, the total lipid of livers was significantly increased ($p<0.05$) in the other two disease groups only when associated with endometritis. The other disease group without endometritis was significant increase ($p<0.05$) more than RDA without endometritis. The results mean that the prevalence of endometritis increased of parallel to as increase the fatty infiltration of livers. In contrast, lactation time had no influence on the lipid contents of livers.

Table 5. Number of affected and non-affected cows with endometritis in different disease condition groups (n=480)

Disease	Endometritis			
	Endometritis		No- Endometritis	
	No	percentage	No	Percentage
Left Abomasal Displacement (n=345)	131	27,3 %	214	44,5 %
Right Abomasal Displacement (n=40)	7	1,5 %	33	6,9 %
Other Diseases (n=95)	27	5,6 %	68	14,2 %
Total (n=480)	165	34,4 %	315	65,6 %

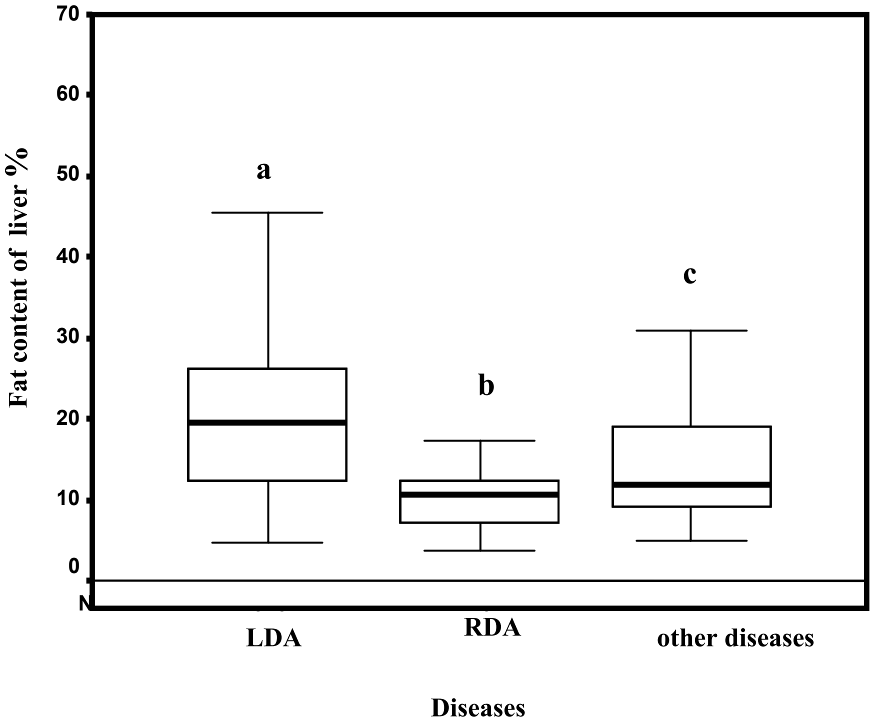


Figure 4. Relationship between fat content of liver and different diseases

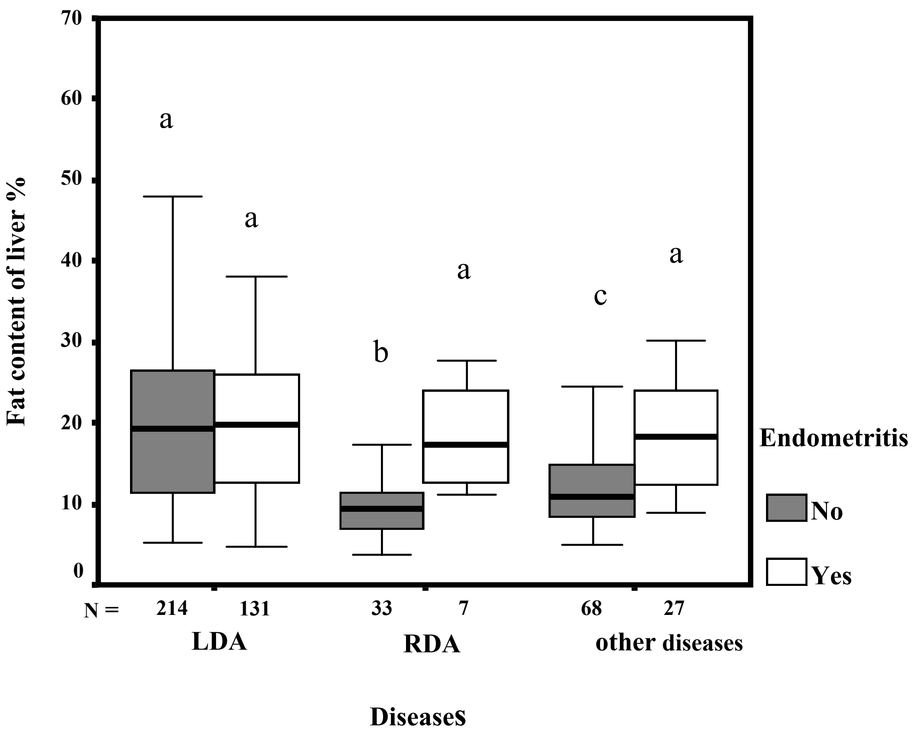


Figure 5. Relationship between different diseases, endometritis and fat content of liver

Same letters in the same row are non significant
Different letters are significant at p<0.05
N = number of animals

4.5 Relationship between fat content, triglyceride and survival rate

Table 6 shows the numbers of dead and recovered animals and their relationship to fat contents of the livers. 70 of the total of 480 cows with a high percentage of dead cows being in the severe fatty liver group.

Related to the different fat liver groups, the mortality rates were 26 cows (11, 9 %) in the normal liver group (n=224) and 24 cows (15,09 %) in the mild fatty liver group (n=159). In the moderate fatty liver group, 11 cows (14, 1%) died from the total of 78 animals in this group. 9 cows (47, 4%) from 19 cows died in the severe fatty liver groups (table 6). A significant increase ($p<0.05$) in mortality rate of cows affected with severe fatty livers compared to other liver conditions is demonstrated. The mortality rate did not significantly vary in the normal, mild and moderate fatty liver groups.

Table 6. Number of dead and recovered animals and their liver fat content

Fat content %	Recovery (N=410)	Death (N=70)	Mortality rate
0 –15,5	198	26	11,90 % a
>15,5 - 26	135	24	15,09 % a
> 26 - 33	67	11	14,10 % a
>33	10	9	47,40 % b

Same letters in the same row are non significant
Different letters are significant at $p<0.05$
N = number of animals

Referring to the classification of livers according to their triglyceride content, it was found that the mortality rates were 11.9 % (34 cows), 4.9 % (6 cows), 26.2 % (11 cows) and 65.5 % (19 cows) in the normal, mild, moderate and severe fatty liver groups respectively (table 7). This result shows that there is a significant increase ($p<0,05$) in the mortality rates in the moderate and severe fatty liver groups compared to the normal and mild fatty liver groups. Moreover, total fat content, total triglyceride content and triglyceride/fat content of livers were significantly increased (p<0,05) in dead compared to live animals (figures 6,7, 8).

Table 7. Number of dead and recovered animals and their liver triglyceride content

Fat content %	Recovery (N=410)	Death (N=70)	Mortality rate
0 –10	252	34	11.9 % a
>10 -15	117	6	4.9 % a
> 15 - 20	31	11	26.2 % b
>20	10	19	65.5 % c

Same letters in the same row are non significant
Different letters are significant at p<0.05
N = number of animals

Figure 6. Relationship between mortality rate and total fat content of livers

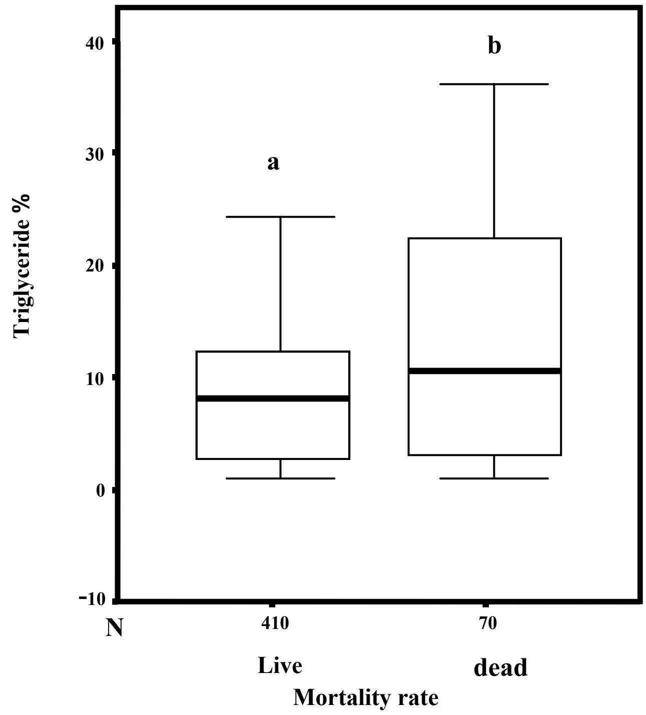


Figure7. Relationship between mortality rate and triglyceride contents of livers

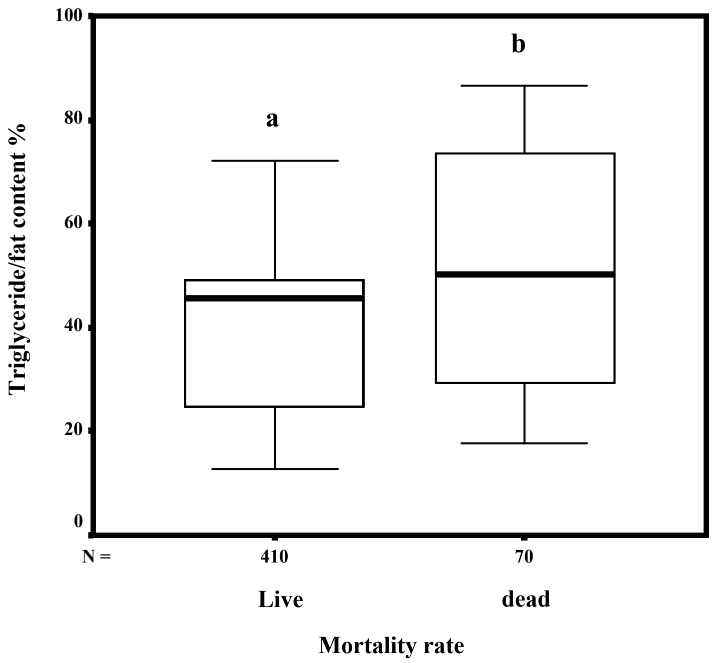


Figure 8. Relationship between mortality rate and triglyceride/fat contents of livers

Same letters in the same row are non significant
Different letters are significant at $p<0.05$
N = number of animals

4.6 Clinical chemistry

The changes in clinical chemistry depend on the severity of the fatty liver. The biochemical changes associated with the fatty liver syndrome in cows have been described based on blood and liver samples taken from animals.

The correlation between liver fat content, triglyceride and triglyceride content of total fat (TG/FC) on one side and some parameters of blood chemistry on the other side are contained in table 8.

There was a significant decrease ($p<0,01$) in mean serum concentrations of phosphorus (P^{+++}) with increases of either fat content of liver, triglyceride amount or of TG/FC (r=-0,35, r=-0,37, r=-0,34, respectively).

Moreover, the mean serum concentration of potassium (K^{+}) also was significantly lower with increasing fat content of liver, triglyceride amount of liver and TG/FC (r=-0,34, r=-0,37, r=-0,29, respectively).

In contrast, the mean concentrations of other macro-elements like sodium (Na^{+}), magnesium (Mg^{++}), calcium (Ca^{++}) and chloride (Cl^{-}) did show no significant correlations with increases in total lipid content, total triglyceride of liver and TG/FC.

Concerning liver enzymes, it was observed that the mean serum concentration of aspertate amino-transferase (ASAT) was significantly increased ($p<0,01$) with increases of the mean fat content of livers(r=0,31), TG (r=0.34) and TG/FC (r= 0.30), while the concentration of glutamate dehydrogenase (GDLH) did not significantly change.

There further also was a significant increase in the mean serum concentration of total bilirubin ($p<0,01$) with elevated mean concentrations of fat content of livers, triglyceride, TG/FC, respective correlation coefficients were r=0, 44, r=0, 49, r=0, 45.

A significant negative correlation ($p<0, 01$) between mean serum concentration of urea on one side and total fat content of livers (r=-0,12) triglyceride (r=-0,10) and TG/FC (r=-0,10) on the other side was also established, but the correlations were weak.

Table 8. Correlations between clinical chemistry and fat %, TG % and TG/FC %

Parameters	Fat %	TG %	TG/FC %
	r	r	r
Magnesium (Mg^{++}) (n=480)	-0.05	-0.06	-0.07
Calcium (Ca^{++})(n=480)	0.06	0.078	0.05
Phosphorus (P^{+++})(n=480)	-0.35**	-0.37**	-0.34**
Sodium (Na^{+})(n=480)	0.01	-0.04	-0.01
Potassium (K^{+}) (n=480)	-0.34**	-0.37**	-0.29**
Chloride (Cl^{-}) (n=480)	0.03	-0.03	0.01
Aspartate amino-transferase (ASAT) (n=480)	0.31**	0.34**	0.30**
Glutamic dehydrogenase (GDLH) (n=52)	0.23	0.27	0.24
Bilirubin (n=480)	0.44**	0.49**	0.45**
Urea (NH_4^{+}) (n=480)	-0.12**	-0.10*	-0.10*

r = Correlation coefficient n = number of animals
** = significant at p<0.01 * = significant at p< 0.05

4.7 Hematology

The correlations between mean concentrations of total fat in livers, triglyceride content of livers and triglyceride contents of total fat content and blood picture are tabulated in table 9. The hematological pictures of examined cows revealed some significant variations with respective increases of total fat contents of liver, triglyceride contents of livers and triglyceride contents of total fat contents.

Noticeable were significant increases ($p<0,01$) of the hematocrite, hemoglobin, mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) with increasing fatty infiltration of the liver($r=0.15$, $r=0.17$, $r=0.33$, $r=0.23$ respectively) on one side and with increasing triglyceride contents of livers ($r=0.14$, $r=0.17$, $r=0.33$, $r=0.24$, respectively) on the other side.

Moreover, hematocrite, hemoglobine, mean corpuscular volume (MCV) were significantly increased ($p<0.05$) with elevation of triglyceride contents of total fat ($r=0.09$, $r=0.12$, $r=0.30$ respectively) while the mean corpuscular hemoglobin (MCH) was significantly increased only ($p<0.01$) with high triglyceride contents of total lipid ($r=0.20$).

In contract, the mean corpuscular hemoglobine concentrations were significantly decreased ($p<0.05$) with increases in total fat contents of livers, triglyceride content of livers and triglyceride contents of total fat content ($r=-0.11$, $r=-0.10$, $r=-0.09$, respectively).

Finally, erythrocytes counts also decreased with increases of either fat content of livers, triglyceride contents of liver or triglyceride contents of total fat content, but these changes were not statistically significant.

It was also found that total leucocyte counts and band cells significantly were reduced ($p<0.01$) in response to increases in total lipid contents of livers ($r=-0.17$, $r=-0.14$ respectively) and to triglyceride contents of livers ($r=-0.17$, $r=-0.14$ respectively). Total leucocyte count was significantly low ($p<0.01$) only with increases in the triglyceride contents of fat ($r=-0.16$) but band cells were significantly decreased ($p<0.05$),($r=-0.12$).

Easinophils were significantly reduced ($p<0.05$) with increasing fat contents of livers, triglyceride contents of livers ($r=-0.13$, $r=-0.14$) but did not decrease significantly with triglyceride contents of total fat contents, while segmented leukocytes and monocytes were decreased with an increase in the fat content of liver. However, the correlation was not significant.

The number of lymphocytes finally was significantly increased (p<0.01) in association with increasing fatty infiltration of livers (r=0.14), as were blood platelets were, although this correlation was not statistically significant.

Table 9. Correlation between blood picture parameters and fat contents of livers

Parameters	Fat %	TG %	TG/FC%
	r	r	r
Hematocrite (PCV) (n=480)	0.15**	0.14**	0.09*
Hemoglobin (Hb) (n=480)	0.17**	0.17**	0.12*
Erythrocytes (RBCs) (n=480)	-0.05	-0.06	-0.08
Mean Corpuscular Volume (MCV) (n=480)	0.33**	0.33**	0.30**
Mean Corpuscular Hemoglobin (MCH) (n=480)	0.23**	0.24**	0.20*
Mean Corpuscular Hemoglobin Conc.(MCHC)(n=480)	-0.11*	-0.10*	-0.09*
Leucocytes (WBCs) (n=480)	-0.17**	-0.17**	-0.16**
Band cells (n=480)	-0.14**	-0.14**	-0.12*
Segmented cells (n=480)	-0.06	-0.08	-0.11*
Lymphocytes (n=480)	0.14**	0.16**	0.17**
Monocytes (n=281)	-0.07	-0.07	-0.08
Blood Platelets (n=431)	0.02	0.03	0.04
Eosinophils (n=248)	-0.13*	-0.14*	-0.14*

r = Correlation coefficient n = number of animal
** = highly significant at p<0.01 * = significant at p<0.05

4.8 Histopathology

The macroscopic picture of liver biopsies is completely different related to the fat contents. In cases of mild or even moderate fatty liver, the picture is not greatly different from the normal liver biopsy, while biopsies of severe fatty livers are completely different, characterized by yellow color, loss of consistency, friable and having a greasy texture.

Microscopically it is so difficult to differentiate between the different concentrations of total liver lipid as estimated by the copper sulfate and gravimetric methods. However, fatty livers can be classified histologically into mild, moderate and severe fatty.

4.8.1 Paraffin section

The histological examination of paraffin sections stained with H&E showed changes in the liver cells. In most cases of fatty liver, hepatocytes throughout the liver had abnormally extensive cytoplasmic vacuoles (pictures 4, 5, 6).

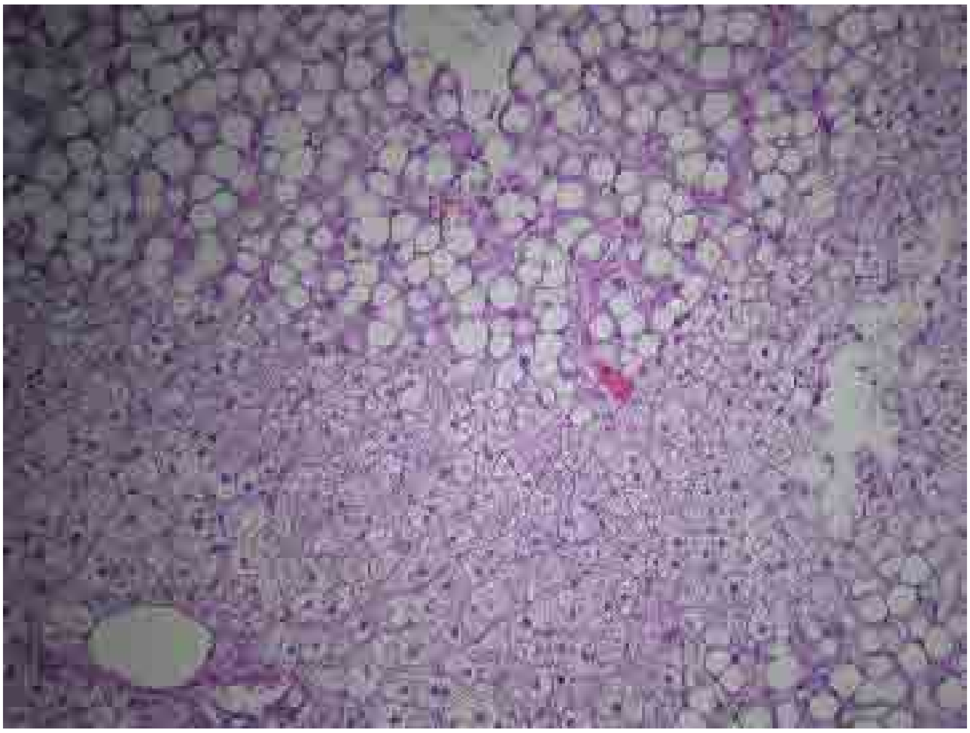
In contrast, in mild fatty livers, it was not possible to differentiate the degree of vacuolation from that found in livers with normal fat content. The affected hepatocytes though were more vacuolated in moderate fatty livers. In mild fatty livers, fat deposits were also identifiable near the portal tract but intercellular deposits were found to radiate progressively out from the region of the tract, along the branches of the different hepatic arteries and the portal vein. Increasing amounts depend on the severity of cases until the parenchyma around the central efferent hepatic veins and throughout the liver are diffusely and heavily infiltrated. Hepatocytes in the mid region contain relatively little lipid in mild cases.

For comparison, in moderate fatty livers, the deposition of fat was centro-lobular and mid-zonal. The entire lobule contains high contents of lipids in severe fatty livers which affects the hepatic structural unit and functions. In severe fatty livers, entire lobules were affected. The nuclei of the liver cells were sometimes slightly enlarged and their nucleoli were prominent. The severe form showed some characteristic signs of degeneration and necrosis.

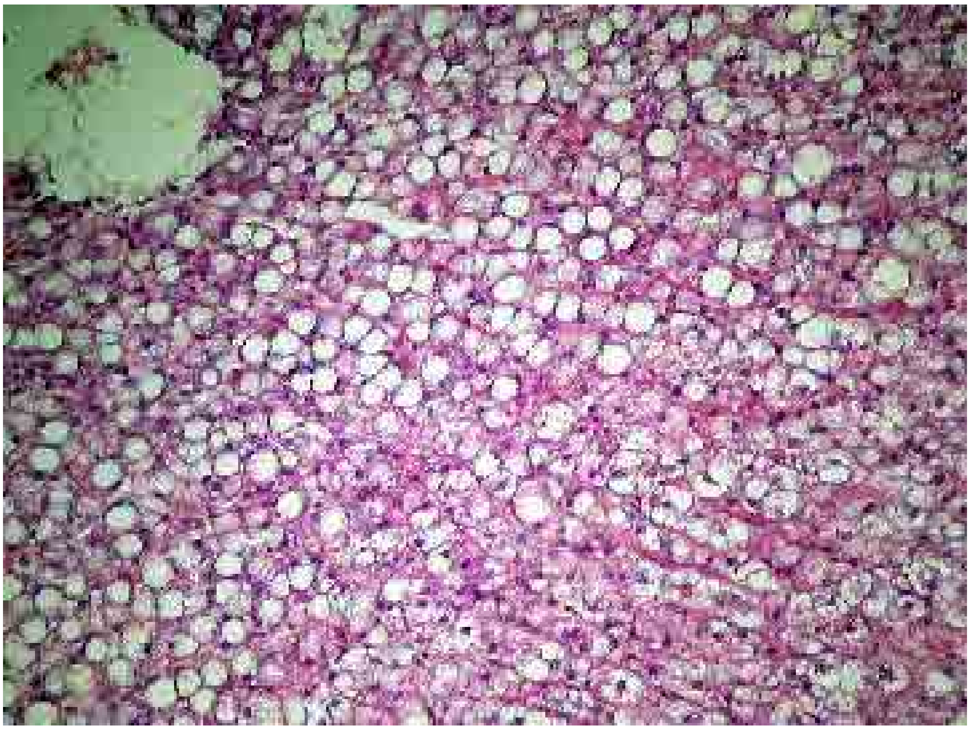
4.8.2 Frozen section

Results of examination of frozen sections stained with Sudan III are shown in picture, 7. The picture reveals a much more widespread and abnormal distribution of lipid in liver tissues of affected cows than suggested by examination of paraffin sections. Excess lipid was invariably present in the hepatic cells. In severe fatty livers, large numbers of droplets of sudanophilic lipid were often seen in hepatocytes close to the larger portal tract structure.

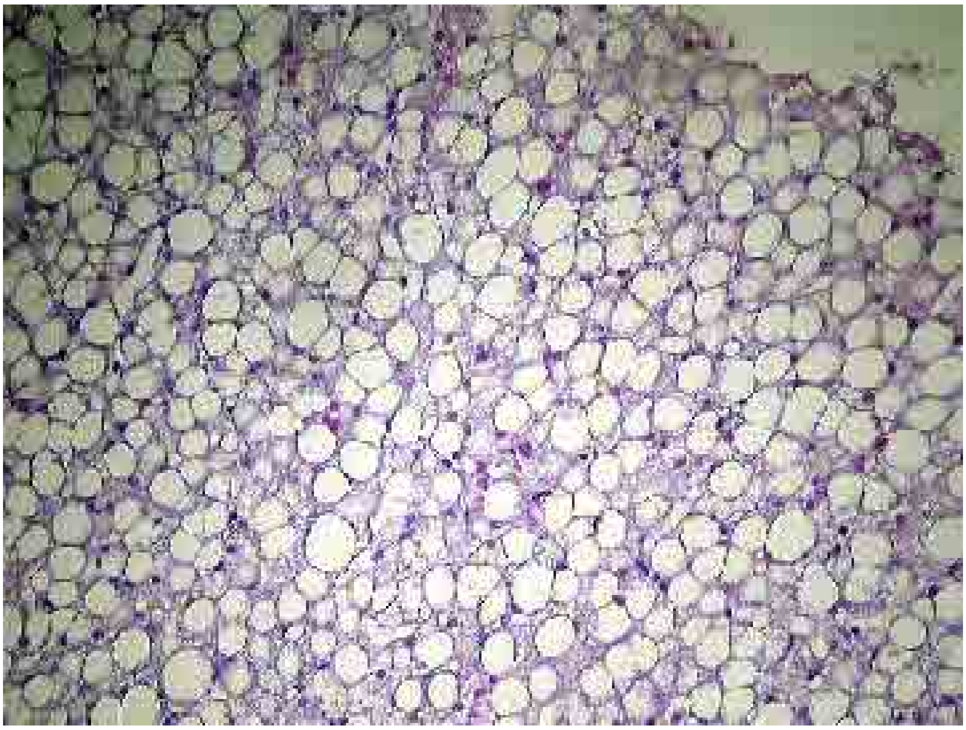
Some liver tissues did exhibit a macroscopical picture completely different from normal liver tissue. The texture was friable but the fat content was within normal range. The histopathological changes of these samples revealed toxic hepatic dystrophy.



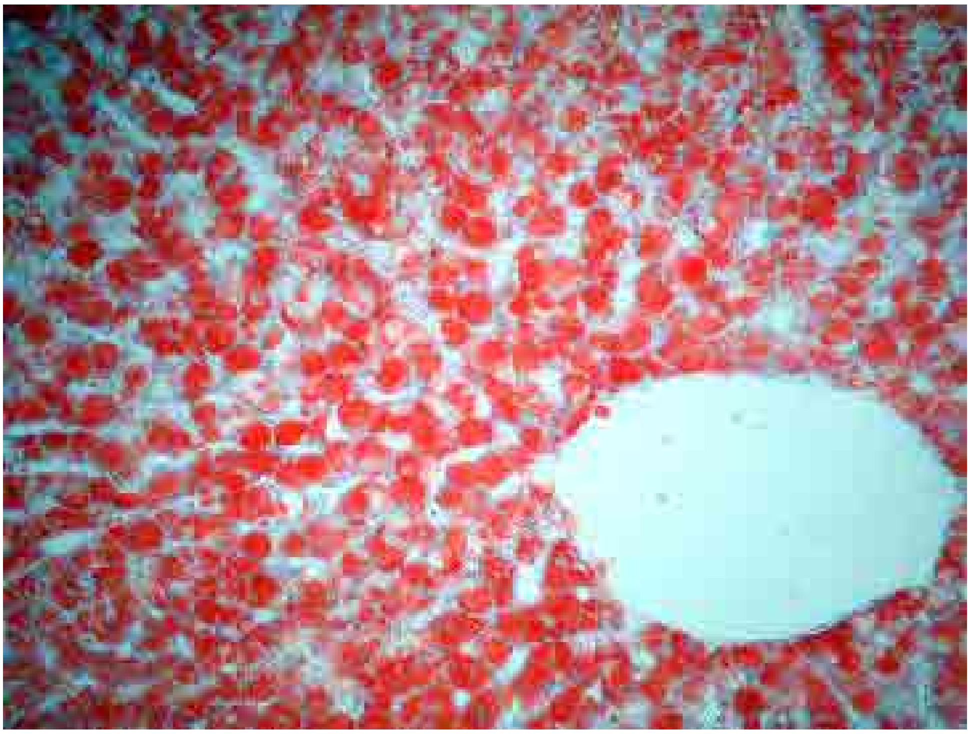
Picture 4. Histopathological picture of mild fatty liver (100x H&E stain)



Picture 5. Histopathological picture of moderate fatty liver (100x H&E stain)



Picture 6. Histopathological picture of severe fatty liver (100x H&E stain)



Picture 7. Histopathological picture of sever fatty liver (100x Sudan III stain)

4.9 Ultrasonographic examination

Ultrasonographic examination was applied for 140 cows with either normal livers or livers with different degrees of fatty infiltration.

It was found that the parenchymal pattern of the normal liver consisted of numerous weak echoes homogeneously distributed over the entire area of the liver (picture 10). The portal vein was clearly observed within a normal liver picture, the wall of this vessel was hyperechoic and its contents did appear black.

The portal vein was observed only in the area of portal fissure and it was characterized by a satellite ramification in this region (picture 8).

The bile duct was not usually visible. The visceral surface of a liver was sometimes difficult to assess when adjacent to the intestine. The gallbladder was visualized only in one inter-costal space, either the 9th or 10th intercostal space, but never in the 11th or 12th intercostal spaces. The ultrasonographical picture of gallbladder gave an image typical of a fluid-filled vesicle (picture 9). The normal gallbladder had a pear-shaped cystic structure with variable size and was easy to recognize.

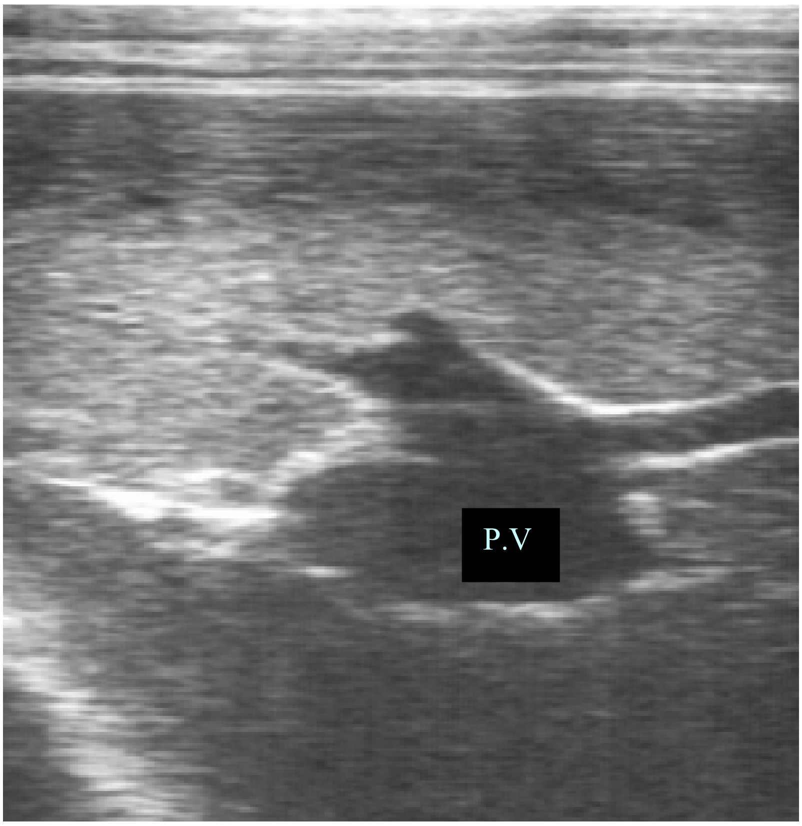
In cases of mild or moderate fatty livers, the ultrasonographic picture did not differ greatly from normal liver parenchyma and was difficult to diagnose by ultrasound.

In contrast, in severe cases, the echoes weaked as the distance from the abdominal wall increased. Consequently, the region near the abdominal wall was hyperechoic (white pattern), whereas areas that were more distant were hypoechoic (dark pattern) or could not be imaged at all (picture 11).

The contrast between the liver and vessels in these cases also is decreased and there exists vascular blurring and blurring of liver edges which lead to poor or no visualization of the portal vein and other intrahepatic vessels.

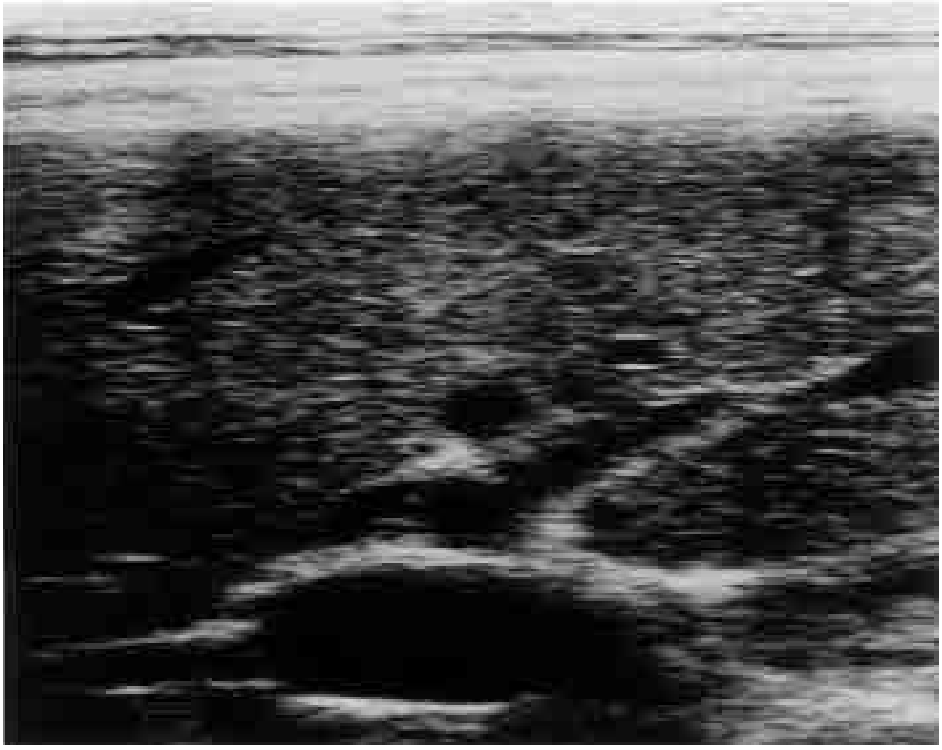
Concerning the different dimension of liver, an increase in the size of livers of cows with a increased total fat content of the liver was not noticeable. Also that size of the gallbladder was significantly ($p<0,01$) increased with a high fat content of the liver ($r=0,82$) (figure 15), while the diameter of the portal vein significantly ($p<0,01$) decreased with increasing fat infiltration of the livers($r=-0.52$) (figure 9).

In case of fatty cows, the ultrasonographic picture of the liver is not clear and anyone cannot accurately judge on the parenchyma and structure of the liver (picture 10).



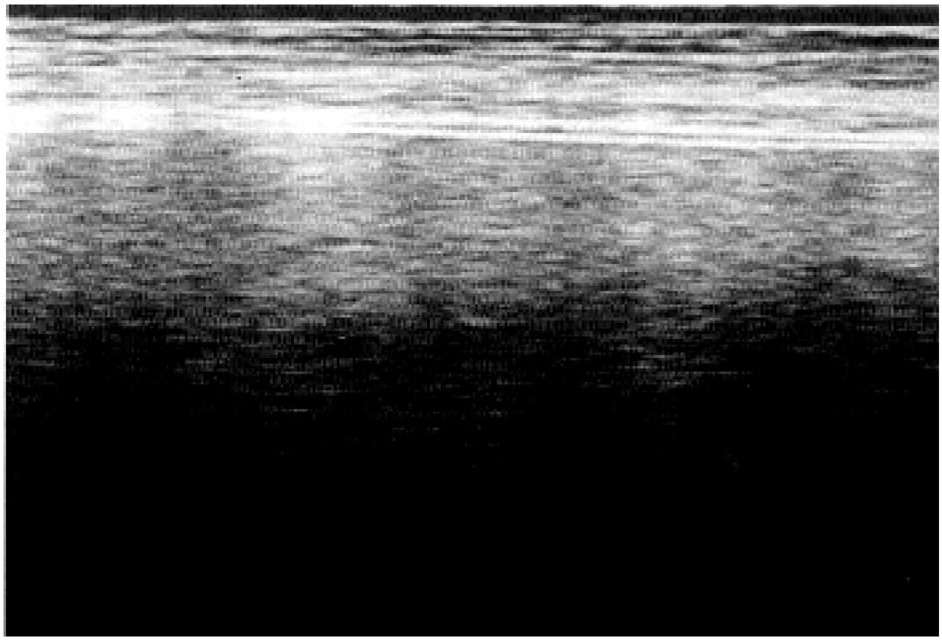
Picture 8. Ultrasonographic picture of portal vein

Picture 9. Ultrasonographic picture of gall bladder



Picture 10. Ultrasonographic picture of normal liver

Picture 11. Ultrasonographic picture of fatty liver



Picture 12. Ultrasonographic picture of liver of fatty cow

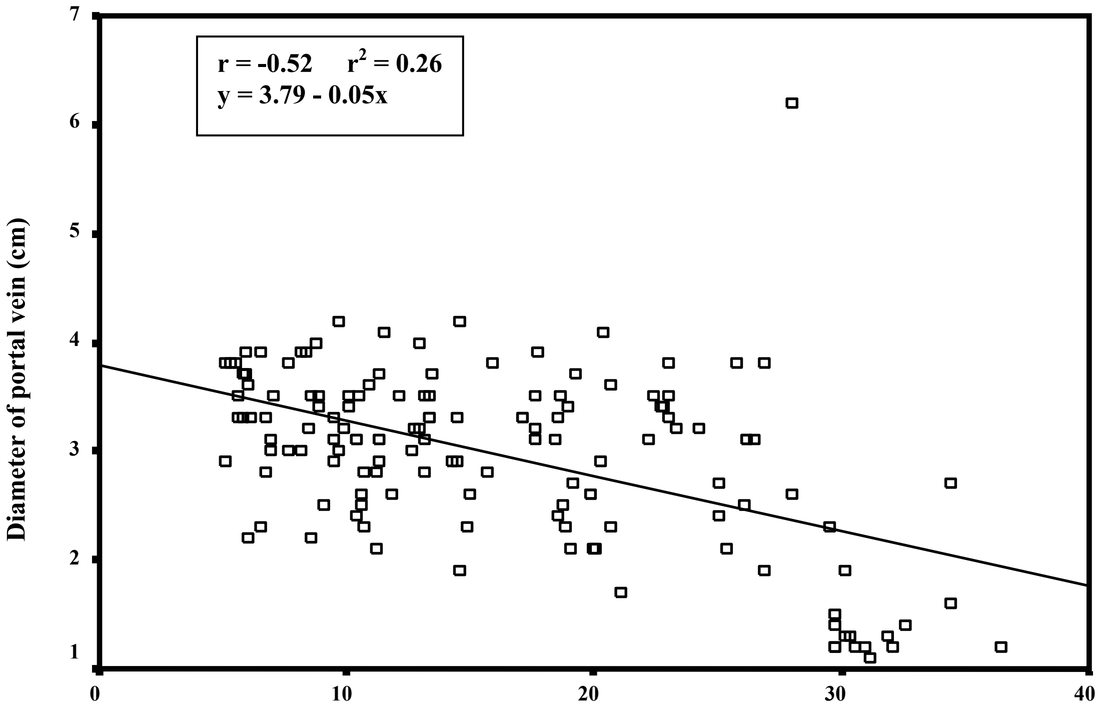


Figure 9. Correlation between portal vein diameter and total fat content of liver

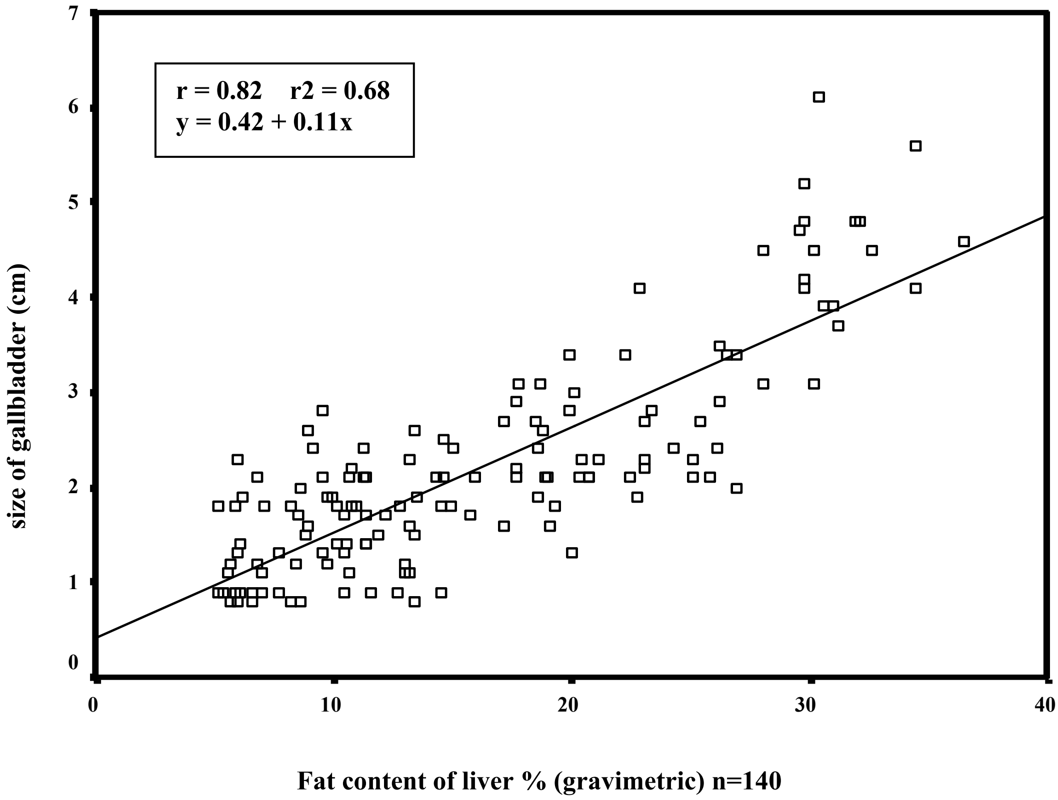


Figure 10. Correlation between size of gall bladder and total fat content of liver