Journal of Sustainable Veterinary & Allied Sciences
P-ISSN-2695-2661 e-ISSN: 2811-1346
JoSVAS 2024 June Vol 6 Issue 2:67 -74

Original Research

Occurrence and correlates of liver damage and dysfunction in Pigs in Umudike, South-East, Nigeria

***[1]Igwe, K.K., [2]Ihedioha, J. I. & [2]Shoyinka, S.V.O.**

[1]Department of Veterinary Biochemistry and Animal Production, Michael Okpara University of Agriculture Umudike, Abia State, [2]Department of Veterinary Pathology, University of Nigeria, Nsukka, Enugu State, Nigeria

**Correspondence:* kkigwe191@gmail.com, +2348035853235

ABSTRACT

This study evaluated the occurrence of liver damage and dysfunction in on-farm pigs reared in Umudike, Abia State, Nigeria. The study was a cross sectional survey. Seven piggeries in Umudike were purposely selected to geographically cover the study area. A total of 151 pigs in seven piggeries were evaluated for liver damage and liver dysfunction. Each of the pigs was subjected to physical examination and based on the physical examination was categorized as apparently healthy or physically unhealthy. Blood samples were collected from the ear vein of each pig into clean labelled sample bottles. The blood was allowed to clot and serum for clinical biochemistry was obtained by centrifugation. The serum was immediately (within 24 hours of collection) evaluated for markers of hepatocellular damage, hepatosynthetic ability and hepatobiliary function following standard spectrophotometric methods. The results obtained were compared with established reference limits and cut-off points. The percentage occurrence of liver damage based on hepatocellular integrity markers (AST and ALT) ranged from 3.97% to 5.96% while the occurrence of liver damage and dysfunction based on hepatobiliary markers (ALP and Bilirubin) ranged from 0% to 5.30%. Based on markers of hepatosynthetic ability, the occurrence of liver damage/dysfunction ranged from 3.97% to 25.82%. When the markers of liver damage/dysfunction were combined, the occurrence of liver damage/dysfunction ranged from 2.65% to 4.64%. For all the markers, the occurrence of liver damage/dysfunction was significantly ($p< 0.01$) associated with the physical health status of the pigs. It was concluded that the occurrence of liver damage and dysfunction in surveyed pigs ranged from 2.65% to 4.64%, when the markers were combined as commonly done clinically. The occurrence was significantly associated with the physical health status of the pigs.

Keywords: Albumin, bilirubin, cholesterol, liver, liver enzymes, pig

INTRODUCTION

Pigs contribute a substantial portion of Nigeria's meat supply (Nwachukwu & Udegbunam, 2020). They are omnivorous animals and can easily be managed and they are efficient in the utilization of feed by-products (FAO, 1999). Pigs are widely distributed in Nigeria but less in the north because of religious reasons. There is a worldwide trend towards the consumption of white meat more than red meat, thus there is increased potential for pork meat production when compared to cattle (FAO, 1999).The levels of the following vitamins has long been established to be higher in pork than beef :- thiamine, riboflavin , niacin, panthotenic acid, vit B_6 , biotin and folic acid, (Price and Schweigert,1971).Therefore consumption of pork meat is considered beneficial for the control of some metabolic diseases (Passmore and Eastwood,1986). Pig meat which is known as pork is particularly suitable for processing and they offer quick turn over rate on investment (Pathiraja, 1986; English *et al*, 1988; FAO, 1999).

Pigs produce meat without deterioration of grazing land and convert concentrates to meat more efficient than ruminants, (Thorne 2017; Nicole, 2017). They are highly productive and are capable of producing large litters and are with short gestation periods. Pigs are simple stomached animals thus they compete directly with humans for food. Pigs and man are co-hosts to a number of parasitic, bacterial and viral diseases, *Trichnella spiralis* in swine and game animals and hydatidosis transmitted via all meat. Animals and humans may become infected by eating the larvae in raw or partially cooked pork products, (Price & Schweigert 1971). Swines are infected by eating raw or partially cooked garbage that contains uncooked meat scraps, (Benbrook, 1958; Soulsby, 1968; Price and Schweigert, 1971), also and toxoplasmosis of parasitic origin. Bacteria diseases that can be transmitted

http://doi.org/10.54328/covm.josvas.2024.154

between pigs and humans include anthrax, brucellosis and streptococcal infection. Viral diseases include Delta coronavirus, African swine fever, Classical Swine fever, Swine influenza and Napah virus disease. Therefore if pigs are not confined they can pose a danger to human health because the above diseases are zoonotic.

The liver of pig is very similar in morphology and function to that of humans, therefore is used as model for human researches. The liver performs a variety of functions and plays very important roles in many metabolic processes, thus it is the most frequently assaulted and damaged organ in the body. It is one of the most versatile and active organ in the body. It produces bile, metabolizes hormones and drugs (Katzung, 2007) synthesizes proteins, glucose, and clotting factors, stores vitamins and minerals, changes ammonia produced by deamination of amino acids to urea and converts fatty acids to ketones, (Guyton and Hall 2006). In its capacity for metabolizing drugs and hormones, the liver serves as an excretory organ (Katzung, 2007). In this respect, the bile, which carries the end products of substances metabolized by the liver, is much like the urine, which carries the body wastes filtered by the kidneys (Guyton and Hall, 2006).

The liver synthesizes albumin which contributes significantly to the plasma colloidal osmotic pressure. It binds and transports numerous substances, including some hormones, fatty acids, bilirubin, and produces other important proteins, such as fibrinogen and the blood clotting factors, (Guyton and Hall, 2006), and a major site of amino acid interconversion, (Crawford, 2005) also synthesis of cholesterol, phospholipids, and lipoproteins.

Serum enzymes have been used by researchers for clinical diagnosis and to confirm organ integrity or dysfunction, (Igwe *et al,* 2024a), screening for toxicological indices, (Igwe *et al* 2023b) or haematological problems (Igwe *et al* 2024b; 2023a). Effect of plant extracts on internal organs and metabolic diseases has been diagnosed using serum enzymes, (Igwe *et al* 2024c)

Only a few reports are available in the literature on spontaneous liver lesions in pigs and there are no reports in available literature on the occurrence of liver damage and dysfunction in pigs in the study area. Therefore this study was designed to evaluate the occurrence and correlates of liver damage and dysfunction in pigs in Umudike, Abia State, Nigeria.

MATERIALS AND METHODS

STUDY DESIGN

This study was a cross-sectional survey of on-farm pigs in Umudike, Abia state, Nigeria. Seven piggeries, which were the major ones in Umudike were purposely selected to cover the study area. A total of 151 pigs from the seven different pig farms were evaluated and all treatment were humane to ensure minimal discomfort was caused to the pigs. Ethical approval was obtained from ethical committee of College of Veterinary Medicine, Michael Okpara University of Agriculture, Umudike (MOUAU/CVM/REC/2024011). Each pig evaluated was subjected to physical examination and the physical health status was recorded. Determination of Serum Alanine amino transferase (ALT) activity, Aspartate amino transferase (AST) activity, Alkaline phosphatase (ALP) activity, Total Protein (TP) Levels, Albumin (Alb) Levels, Globulin (Glob) Levels, Total Bilirubin (T.Bil) Levels and Total Cholesterol (T.Chol) was done. Reference levels were used as markers of liver damage/dysfunction abbreviated as Upper Reference Limit (URL) and Lower Reference Limit (LRL).

BLOOD COLLECTION AND BIOCHEMICAL ASSAY

Blood samples were collected from the ear vein and allowed to clot for 45 minutes. The clotted blood was centrifuged to obtain the clear serum for the biochemical assays. All the biochemical assays followed standard spectrophotometric procedures, and were done within 24 hours of sample collection.

Serum biochemical assay procedures of Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) were done using Reitman and Frankel colorimetric method (Reitman and Frankel, 1957; Colville 2002). Alkaline phosphatase serum assay (ALP) was done using Phenolphthalein monophosphate method (Klein *et al*., 1960; Babson *et al*., 1966). Total protein was by Biuret method (Lubran, 1978; Johnson, 2008). Albumin determination was by Bromocresol green (BCG) reaction (Johnson, 2008). Globulin was calculated by subtraction of albumin from total protein levels (Johnson, 2008). Total bilirubin was by Modified Jendrassik-Grof method (Doumas, *et al.* 1973; Higgins *et al.* 2008) Total cholesterol was by Enzymatic colorimetric method (Allain *et al.*, 1974; Rifai *et al.*, 2008).

These Diagnostic tests help to evaluate liver function and the extent of liver damage and were used in the laboratories to assess liver function and confirm the diagnosis of liver damage and dysfunction. Liver function tests, including serum levels of liver enzymes, were used to assess hepatocellular damage, hepatosyntheic ability and hepatobiliary damage, (Pratt and Kaplan, 2000). For hepatocellular damage, the key enzymes used were alanine aminotransferase (ALT) and aspartate aminotransferase (AST), which in most cases of liver damage, show parallel rises as seen in cases of acute hepatocellular injury, viral hepatitis, hypoxic, ischemic injury, acute and toxic injury, (Pratt and Kaplan 2000).The liver's synthetic ability is reflected in measures of serum protein, albumin, and cholesterol levels. Hypoalbuminemia and cholestrolnemia showed depressed synthesis which may occur in liver

diseases. Serum bilirubin, and alkaline phosphatase (ALP) measure hepatic excretory function and elevation in blood suggests excretory difficulty of the liver, (Pratt and Kaplan, 2000).

STATISTICAL ANALYSIS

Data obtained were subjected to descriptive analysis and presented as percentages. Possible associations between liver damage/dysfunction and health status were analysed using Chi square and Fisher's exact t-test as appropriate. Correlation between the different markers of liver damage was analysed using Pearson correlation coefficient. SPSS 16.0 version was used for the analysis. Significance was accepted at $p \leq 0.05$.

Established reference limits in literature were used as cut off points for damage or dysfunction, (Radostits *et al*, 2000). (Table I)

Table 1. Reference limits for the markers of liver damage/dysfunction in pigs.

Markers	Reference range
AST	32-48 mg/dl
ALT	31-58 mg/dl
ALP	120-400 mg/dl
Cholesterol	28-48 mg/dl
Albumin	1.9-2.4 g/dl
Bilirubin	0-1.0 mg/dl

RESULTS

DEMOGRAPHY

A total of 151 pigs were sampled, out of which 39 were adjudged as unhealthy based on physical examination, while 112 were categorized as apparently healthy.

OCCURRENCE OF LIVER DAMAGE/DYSFUNCTION

Based on the reference intervals for the markers of hepatocellular integrity (ALT and AST activity), seven (7) out of the total of 151 pigs sampled (4.64%) had their serum ALT activity above the 58 IU/L upper reference limit (URL), while nine (9) pigs (5.96%) had their serum AST activity above the 84 IU/L URL (Figure 1). Only six pigs out of the 151 sampled (3.97%) had both their serum ALT and AST above the URL (Figure I).

When the reference limits for markers of hepatic synthetic ability (serum levels albumin and cholesterol) were used as criteria, 39 out of the 151 (25.82%) had their serum albumin levels below the 1.9 g/dl lower reference limit (LRL), while 10 out of the 151 (6.6%) had their serum cholesterol levels below the 28 mg/dl LRL (Figure II). Six (6) pigs out of the 151 sampled (3.97%) had both their serum albumin and cholesterol levels below the LRL (Figure II).

Based on the markers of hepatobiliary damage/dysfunction (serum levels of bilirubin and serum ALP activity), eight (8) out of the 151 pigs sampled (5.30%) had their serum bilirubin levels above the 1.0 ml/dl URL, and none of the pigs sampled (0 out of the 151 = 0%) had their serum ALP activity above the 400 IU/L URL (Figure III).

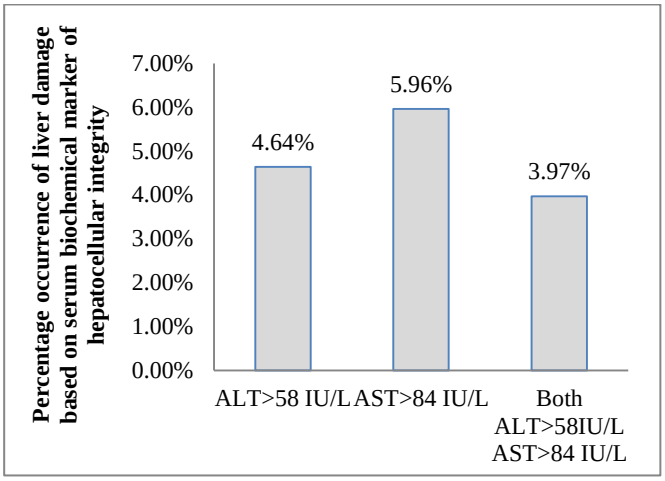

Figure I. The occurrence of liver damage based on the serum biochemical markers of hepatocellular integrity – serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) activities.

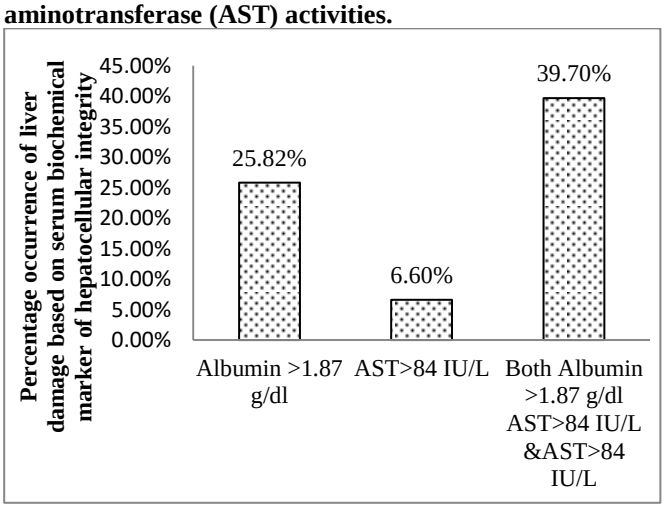

Figure II. The occurrence of liver dysfunction based on the serum biochemical markers of hepatic synthetic ability – serum albumin and cholesterol levels.

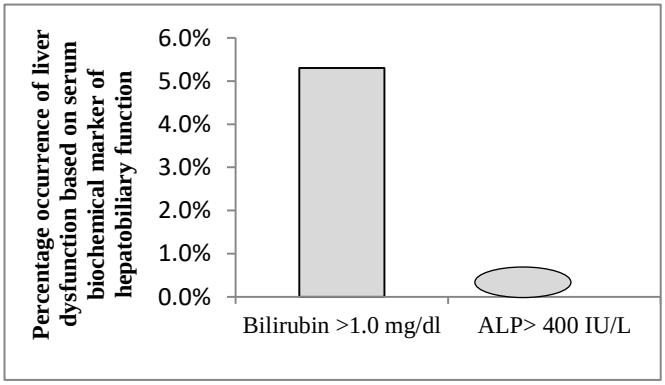

Figure III. The occurrence of liver dysfunction based on the serum biochemical markers of hepatobiliary function – serum levels of bilirubin and serum ALP activity

In the combination of liver markers, elevated AST, ALT and decreased Albumin, Cholesrerol levels, 5 out of 151 pigs were recorded representing (3.31%). (Fig IV)

When the various categories of markers of liver damage/dysfunction were jointly used as criteria, five (5) out of the 151 pigs sampled (3.31%) had their serum ALT and AST activity above the URL and their serum levels of albumin and cholesterol below the LRL (Figure IV). When the markers of hepatocellular integrity (ALT and AST) were combined with a hepatobiliary marker (serum bilirubin), it was found that four (4) out of the 151 pigs (2.65%) had their serum ALT, AST and bilirubin above the URLs (Figure IV). Seven (7) pigs out of the 151 sampled (4.64%) had both their serum albumin and cholesterol levels below the LRL and their serum bilirubin above the URL (combination of the hepatosynthetic and hepatobiliary markers) [Figure IV].

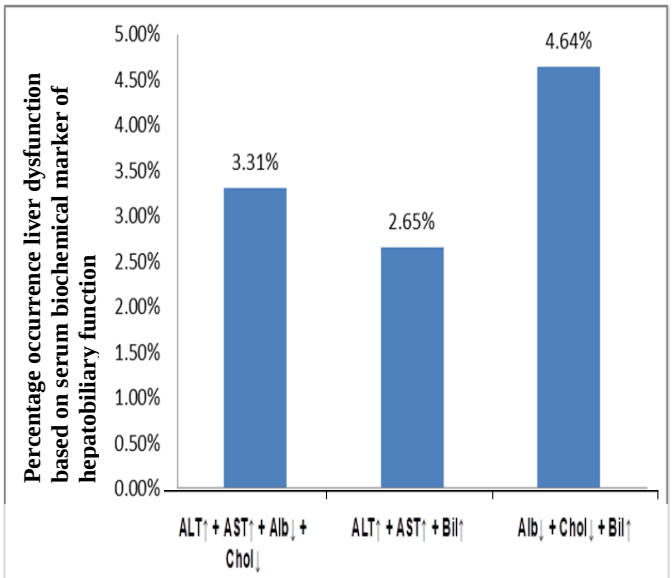

Figure IV. The occurrence of liver damage/dysfunction based on a combination of the serum biochemical of hepatocellular damage, hepatic synthetic ability and hepatobiliary function

RELATIONSHIP BETWEEN THE MARKERS OF LIVER DAMAGE/DYSFUNCTION AND THE PHYSICAL HEALTH STATUS OF THE PIGS

A significantly (p = 0.013) higher proportion of the physically unhealthy pigs (5 out of 39 = 12.8%) had their serum ALT activity above the URL when compared to the 1.8% of the apparently healthy (2 out of 112) [Table II].

Also, a significantly (p = 0.001) higher proportion of the physically unhealthy pigs (7 out of 39 = 17.9%) had their serum AST activity above the URL when compared to 1.8% (2 out of 112) recorded for the apparently healthy (Table III).

Table II. Contingency table showing the relationship between the health status and occurrence of serum alanine aminotransferase (ALT) activity above the upper reference limit in the pigs sampled. *Level of significance, p = 0.013 (Fishers Exact test)*

	Number out of the total, with percentage in brackets		
	Physically Unhealthy	**Apparently healthy**	**Total**
No of pigs with serum ALT activity > 58 IU/L.	5 (12.8%)	2 (1.8%)	**7**
No of pigs with serum ALT activity ≤ 58 IU/L.	34 (87.2%)	110 (98.2%)	**144**
Totals	**39**	**112**	**151**

Table III. Contingency table showing the relationship between the health status and occurrence of serum aspartate aminotransferase (AST) activity above the upper reference limit in the pigs sampled. *Level of significance, p = 0.001 (Fishers Exact test)*

	Number out of the total, with percentage in brackets		
	Physically Unhealthy	**Apparently healthy**	**Total**
Number of pigs with serum AST activity > 84 IU/L.	7 (17.9%)	2 (1.8%)	**9**
Number of pigs with serum AST activity ≤ 84 IU/L.	32 (82.1%)	110 (98.2%)	**142**
Totals	**39**	**112**	**151**

Table IV. Contingency table showing the relationship between the health status and occurrence of a combination of serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) activities above the upper reference limits in the pigs sampled. Level of significance, p = 0.005 (Fishers Exact test)

	Number out of the total, with percentage in brackets		
	Physically Unhealthy	**Apparently healthy**	**Total**
Number of pigs with serum ALT activity > 58 IU/L.	5 (12.8%)	2 (1.8%)	**7**
Number of pigs with serum ALT activity ≤ 58 IU/L.	34 (87.2%)	110 (98.2%)	**144**
Totals	**39**	**112**	**151**

Five (5) out of the 39 physically unhealthy pigs (12.8%) had both their serum ALT and AST activity above the URL, and this was significantly (p = 0.005) higher than the the 0.9% (1 out of 112) recorded for apparently healthy pigs (Table IV)

Significantly (p = 0.000) higher proportion of physically unhealthy pigs (31 out of the 39 = 79.5%) had their serum albumin levels below the LRL, when compared to 7.1% (8 out of 112) apparently healthy ones with their serum albumin levels below the LRL (Table V).

Also, significantly (p = 0.003) higher proportion of unhealthy pigs (7 out of 39 = 17.9%) had their serum cholesterol levels below the LRL, when compared to the 2.7% (3 out of the 112) of the apparently healthy (Table VI).

Six (6) out of the 39 physically unhealthy pigs (15.4%) had both their serum albumin and cholesterol levels below the LRL, while none of the 112 apparently healthy pigs (0%) had both their serum levels of albumin and cholesterol below the URL, and the difference in proportions between the physically unhealthy and apparently healthy was significant (p = 0.000) [Table VII].

Eight (8) out of the 39 physically unhealthy pigs (20.5%) had their serum bilirubin above the URL, while none of the apparently healthy ones (0%) had their serum bilirubin levels above the URL (Table VIII), and the difference between them was significant (p = 0.000).

CORRELATIONS BETWEEN THE DIFFERENT BIOMARKERS OF LIVER DAMAGE AND DYSFUNCTION IN THE PIGS SAMPLED.

The correlation coefficient and level of significance of the correlation of the different parameters/markers of liver damage/dysfunction is presented in Table 9. The serum AST activity of the pigs sampled was significantly and positively correlated with their serum ALT activity (r = 0.502; p = 0.000), serum ALP activity (r = 0.249; p = 0.002), and serum bilirubin levels (r = 0.345; p = 0.000), but was inversely significantly related to their serum levels of cholesterol (r = - 0.171; p = 0.036). The serum ALT activity however was significantly directly (positively) correlated to the serum AST activity (r = 0.502; p = 0.000), serum ALP activity (r = 0.278; p = 000) and serum bilirubin levels (r = 0.428; p = 0.000), but was significantly inversely (negatively) correlated to the levels of total protein (r = - 0.291; p = 0.000), albumin (r = - 0.245; p = 0.002), globulin (r = - 0.275; p = 0.002) and cholesterol (r = - 0.340; p = 0.000).

The correlation between the serum ALP activity and other parameters was significant and positive for serum AST activity (r = 0.249; p = 0.002), serum ALT activity (r = 0.278; p = 0.001) and serum bilirubin levels (r = 0.386; p = 0.000), but was significantly negative (inverse) for serum cholesterol levels (r = - 0.183; p = 0.024). The serum total protein levels was significantly positively correlated to the serum albumin (r = 0.874; p = 0.000) and globulin levels (r = 0.929; p = 0.000), but was inversely significantly correlated to the serum ALT activity (r = - 0.291; p = 0.000) and serum bilirubin levels (r = - 0.347; p = 0.000).

The serum albumin levels was positively and significantly correlated to the serum total protein (r = 0.874; p = 0.000) and globulin levels (r = 0.633; p = 0.000), but inversely significantly correlated to the serum ALT activity (r = 0.245; p = 0.002) and serum bilirubin (r = - 0.347; p = 0.000). The serum globulin levels was significantly positively correlated to only the serum protein (r = 0.929; p = 0.000) and albumin (r = 0.633; p = 0.000), but was significantly inversely correlated with the serum ALT activity (r = - 0.275; p = 0.001) and serum bilirubin (r = - 0.285; p = 0.000). The serum cholesterol levels was significantly inversely correlated with the serum AST activity (r = - 0.171; p = 0.036), serum ALT activity (r = - 0.340; p = 0.000), serum ALP activity (r = - 0.183; p = 0.024) and serum bilirubin levels (r = - 0.285; p = 0.000).

The serum levels of bilirubin was strongly significantly correlated to all the other parameters – it was significantly positively correlated to the serum AST activity (r = 0.345; p = 0.000), serum ALT activity (r = 0.428; p = 0.000) and serum ALP activity (r = 0.386; p = 0.000), but was significantly inversely correlated to the serum total protein (r = 0.347; p = 0.000), serum albumin levels (r = - 0.349; p = 0.000), serum globulin (r = - 0.285; p = 0.000) and serum cholesterol levels (r = - 0.350; p = 0.000).

DISCUSSION

The recorded occurrence of liver damage/dysfunction in the pigs sampled in this study which ranged from 2.65% to 6.6% (depending on which parameter or parameter combinations were used) is relatively low when compared to reports of occurrence of liver diseases in humans and animals in available literature. The comparatively low occurrence recorded in this study is thought to be due to the fact that this present study was an on-farm cross sectional survey in contrast to the reports in literature which are commonly hospital-based or abattoir/necropsy based studies. The 2.65 – 6.6% occurrence recorded in this study is lower than the 7.9% prevalence of liver disease admissions reported in a Nigerian tertiary hospital (University of Nigeria Teaching Hospital, Ituku Ozala) by Nwokediuko *et al* (2013) in their retrospective study covering January 2005 to December 2010. The results obtained in this present study however concur with the 3.9% to 6.9% reported on humans from various ethnic groups by Setiawan *et al* (2016).

When compared with reports on animal studies, the results obtained in the present study is relatively lower than the 16.3 – 18.5% reported occurrence of liver lesions in cattle, goats and sheep slaughtered at an abattoir in Arusha Tanzania (Mellau *et al*., 2010), and also the 24.1% occurrence of lesions on the livers of cattle slaughtered in North Island of New Zealand (Laven *et al*., 2021). It should be noted that these higher values reported for abattoir-based studies are for grossly observed lesions, and that not all grossly observed lesions may translate to significant alterations in the clinical chemistry markers of liver damage/dysfunction. In fact reasonable damage will need to be done on the liver and its functions before these serum biomarkers will exceed their reference limits (Gowda *et al*., 2009). A retrospective hospital-based study on dogs and cats reported a 1.24% prevalence of liver diseases in dogs and 0.41% in cats (Apalkova 2012); this is relatively lower than the 2.65 – 6.6% recorded in this study. A necropsy based report by Watson *et al*. (2010) on dogs however reported 12% prevalence for dogs presented for post-mortem examination.

The single high occurrence (25.82%) of serum albumin levels below the lower reference limits (LRL) in the pigs sampled may possibly be as a result of analytical error, as no

Table V. Contingency table showing the relationship between the health status and occurrence of serum albumin levels below the lower reference limit in the pigs sampled.

	Number out of the total, with percentage in brackets		Total
	Physically Unhealthy	Apparently healthy	
Number of pigs with albumin levels < 1.9 g/dl	31 (79.5%	8 (7.1%)	**39**
Number of pigs with albumin levels ≥ 1.9 g/dl	8 (20.5%)	104 (92.9%)	**112**
Totals	**39**	**112**	**151**

Table VI. Contingency table showing the relationship between the health status and occurrence of serum cholesterol levels below the lower reference limit in the pigs sampled.

	Number out of the total, with percentage in brackets		Total
	Physically Unhealthy	Apparently healthy	
Number of pigs with cholesterol levels < 28 mg/dl.	7 (17.9%)	3 (2.7%)	**10**
Number of pigs with cholesterol levels ≥ 28 mg/dl.	32 (82.1%)	109 (97.3%)	**141**
Totals	**39**	**112**	**151**

Table VII. Contingency table showing the relationship between the health status and occurrence of a combination of serum albumin and cholesterol below the lower reference limit in the pigs sampled.

	Number out of the total, with percentage in brackets		Total
	Physically Unhealthy	Apparently healthy	
No of pigs with a combination of serum albumin < 1.9g/dl and cholesterol < 28 mg/dl.	6 (15.4%)	0 (0%)	**6**
No of pigs with a combination of albumin ≥ 1.9g/dl and cholesterol ≥ 28 mg/dl	33 (84.6%)	112 (100%)	**145**
Totals	**39**	**112**	**151**

Table VIII. Contingency table showing the relationship between the health status and occurrence of serum bilirubin levels above the upper reference limit in the pigs sampled.

	Number out of the total, with percentage in brackets		Total
	Physically Unhealthy	Apparently healthy	
Number of pigs with bilirubin levels > 1.0 mg/dl.	8 (20.5%)	0 (0%)	**8**
Number of pigs with bilirubin levels ≤ 1.0 mg/dl.	31 (79.5%)	112 (100%)	**143**
Totals	**39**	**112**	**151**

Table IX. Correlations between the different biomarkers of liver damage and dysfunction in the pigs sampled.

		AST	ALT	ALP	Total protein	Albumin	Globulin	Cholesterol	Bilirubin
AST	Pearson r	1	.502(**)	.249(**)	-.135	-.134	-.112	-.171(*)	.345(**)
	Sig. (p)		.000	.002	.097	.102	.170	.036	.000
ALT	Pearson r	.502(**)	1	.278(**)	-.291(**)	-.245(**)	-.275(**)	-.340(**)	.428(**)
	Sig. (p)	.000		.001	.000	.002	.001	.000	.000
ALP	Pearson r	.249(**)	.278(**)	1	-.131	-.095	-.137	-.183(*)	.386(**)
	Sig. (p)	.002	.001		.109	.248	.093	.024	.000
Tot. protein	Pearson r	-.135	-.291(**)	-.131	1	.874(**)	.929(**)	.076	-.347(**)
	Sig. (p)	.097	.000	.109		.000	.000	.353	.000
Albumin	Pearson r	-.134	-.245(**)	-.095	.874(**)	1	.633(**)	.068	-.349(**)
	Sig. (p)	.102	.002	.248	.000		.000	.407	.000
Globulin	Pearson r	-.112	-.275(**)	-.137	.929(**)	.633(**)	1	.071	-.285(**)
	Sig. (p)	.170	.001	.093	.000	.000		.385	.000
Cholesterol	Pearson r	-.171(*)	-.340(**)	-.183(*)	.076	.068	.071	1	-.350(**)
	Sig. (p)	.036	.000	.024	.353	.407	.385		.000
Bilirubin	Pearson r	.345(**)	.428(**)	.386(**)	-.347(**)	-.349(**)	-.285(**)	-.350(**)	1
	Sig. (p)	.000	.000	.000	.000	.000	.000	.000	

other parameter or criteria (even total cholesterol, which is also a marker of hepato-synthetic ability of the liver) yielded such an outstanding high occurrence. Proteins are synthesized by the liver in the company of lipids as lipoproteins, thus a deficiency in the synthesis of proteins will also occur concurrently with a deficiency in the synthesis of lipids (total cholesterol). Future further studies on the serum proteins of pigs may clarify this.

The consistent finding in this present study that a significantly higher number of the physically unhealthy pigs had their serum biochemical markers of liver damage/dysfunction beyond the established reference ranges is a pointer to the fact that liver damage/dysfunction is a major contributory factor to morbidity in pig farms, and that the physical health status may serve as a possible outward indicator of liver damage/dysfunction (Rutgers, 1996; Davoudi *et al*., 2013; Thawley, 2017).

The relatively high positive correlation between serum ALT and AST activities (r = 0.502) is a confirmation that, as in humans, both enzymes (ALT and AST) are parallel markers of hepatocellular integrity (Gowda *et al*., 2009). The very high positive correlation between serum total proteins and serum albumin (r = 0.874) and serum globulins (r = 0.929) are expected because albumins and globulins are the major components of serum total proteins. The relatively strong and highly significant relationship between the serum bilirubin levels and all other markers of liver damage/dysfunction in the pigs sampled is a pointer to the fact that serum bilirubin levels is an important biomarker of liver damage/dysfunction in pigs, and its assay should be given reasonable attention in the evaluation of liver damage/dysfunction in these species.

CONCLUSION

The occurrence of liver damage / dysfunction in the pigs in this study ranged from 2.65 – 6.60% depending on the liver function marker used or the combination of markers used. The sensitivity of the various markers in relation to the health status of the pigs ranged from 70 – 100% depending on the marker being considered. The correlation coefficient of one liver function on another, ranged from 0.068 to 0.929, depending on the pair being correlated. Therefore The occurrence (2.65 – 6.6 %.) and correlates of liver dysfunction as observed in the present work indicate the spectrum of pathological conditions in liver of pigs in some farms in Umudike, Abia State in Nigeria. Therefore social distancing between pigs and man should be strictly adhered to in order to avoid transmission of the zoonitic diseases that are prevalent in pigs in this study area.

ACKNOWLEDGMENT

We are grateful to Dr Daniel C. Ifenkwe for blood samples we collected together in farms, Mrs Ngozi Okite for the spectrophotometric analysis and Staff of Vet Biochemistry Laboratory, Michael Okpara University of Agriculture, Umudike for their assistance towards the success of this work.

CONFLICT OF INTEREST

No conflict of interest declared by the authors.

REFERENCES

Allain, C.C., Poon, L.S., Chan, C.S., Richmond, W. & Fu, P.C. (1974) Enzymatic Determination of total Cholesterol. *Clinical Chemistry* 20 (4), 470-475

Apalkova, I. (2013) Prevalence and diagnosis of liver diseases in dogs and cats at the small animal university hospital (2007 – 2010) – A retrospective study. Licentaiate Thesis in Veterinary Medicine. Department of Equine and Small Animal Medicine, Faculty of Veterinary Medicine, University of Helsinki. http://hdl.handle.net/10138/39611

Babson, A.L., Greeley, S.J., Coleman, C.M., & Philips, G.E. (1966) Phenolphthalein monophoshpate as a substrate for serum alkaline phosphate. *Clinical Chemistry* 12, 482-490

Benbrook,,E..A.,(1958) Outline of Parasites for Domesticated Animals in North America, 5th ed. (Iowa State University Press, Ames).

Colville, J. (2002) Blood chemistry. In: Hendrix, C.M. (Ed), Laboratory Procedures for Veterinary Technicians. 4th ed. Mosby Inc. Missouri, USA, pp. 75 - 103.

Crawford, J. M. (2005). Liver and biliary tract. In Kumar Y., Abbas A. K., & Fausto, N. (Eds), *Robbins and Cotran pathologic basis of disease* (7th ed. Pp. 877-937).Philadelphia: Elsevie Saunders.

Davoudi, S.M., Eshagian, M., & Edalatinasab, M. (2013) Overview of hepatic diseases in large animals. *Advances in Bioresearch*, 4(4), 12 – 20.

Doumas, B. T., Perry, B.W., Sasse, E.A., & Straumfjord ,Jr.J.V. (1973) Standardization in bilirubin assay: evaluation of selected methods and stability of bilirubin solution. *Clinical Chemistry* 19, 984-993

English, P.R., Fowler, Y.R., Baxter, S. & Smith, W.J. 1988. *The Growing and Finishing Pig: Improving Efficiency*. Farming Press: Ipswich, UK.

FAO (1999) *Quarterly Bulletins of Statistics.* Food and Agriculture Organisation of the United Nations (FAO): Rome, Italy

Gowda, S., Desai, P.B., Hull, V.V., Math, A.A.K., Vernekar, S.N., & Kulkani, S.S. (2009) A review on laboratory liver function tests. *The Pan African Medical Journal*, 3: Article 17.

Guyton, A., & Hall, J. E. (2006). *Textbook of medical physiology* (11th ed., pp. 799-804). Philadelphia: *Elsevier Saunders.*

Higgins, T., Beutler, E. & Doumas, B.T. (2008) Bilirubin. Analytical Methodology – Serum bilirubin. In: Burtis, CA, Ashwood ER & Bruns DE (Eds.), Tietz Fundamentals of Clinical Chemistry. 6th ed. *Saunders Elsevier, Missouri,* pp. 524 - 525.Igwe, K.K., Achi N.K., Madubuike A.J., Chika Ikenga, Nwatu, S.N., Onyenze, C.J., Otuokere, I.E., Ijeh, I.I., & Aba P. E. (2024a). Effect of *Alternanthera dentata* ethanol

extract on phenylhydrzine induced anaemia, serum biochemistry; GCMS and molecular docking study in rats. *World Journal of Pharmaceutical Sciences*, 13(3), 8-29

Igwe, K.K., Ebuzor, Q.N., Chika Ikenga, Madubuike, A.J., Achi, N.K., Otuokere, I.E., Ijeh,,I.I., & Aba P.E. (2024b). Antidiabetic effect of *Andrographis paniculata* leaves; Hematology and serum biochemistry; GCMS and molecular docking study in rats. *World Journal of Pharmaceutical and Medical Research*, 10 (3), 15-28)

Igwe, K.K., Madubuike, A.J., Achi, N.K. , Chika Ikenga, Nwatu, S.N., Onyenze, C.J., Otuokere, I.E., Ijeh, I.I., & Aba, P.E. (2024c). Anti-anaemic effect of *Manihot esculenta* leaves on phenylhydrzine induced anaemia, serum biochemistry; GCMS and molecular docking study in rat. *World Journal of Pharmaceutical and Medical Research*, 10 (3), 29-41

Igwe, K.K., Madubuike, A.J., Udeh, N.E., Chika Ikenga, Onyenze, C.J., & Nwatu S.N., (2023a). Excitability effect of extract of *Datura stramonium* leaves;Serum Biochemistry and Haematology in rats. Vol. 9 (8), 111-121

Igwe, K.K., Udeh, N.E., Madubuike, A.J., Ibeji, S.I., Onyenze, C.J., & Nwatu S.N., (2023b). Response of Administration of *Panicum maximum* Ethanol Leaf Extract on Tissue weight gain, Biochemical and Haematological indices in Rabbits. *World Journal of Pharmaceutical and Life Sciences*, Vol. 9 (9), 78-87

Katzung, B. G. (2007). *Basic and clinical pharmacology* (10th ed., pp. 50-63). New York: McGraw-Hill Medical

Klein, B., Read, P.A., & Babson, A.L. (1960), Rapid method for the quantitative determination of serum alkaline phosphatase. *Clinical Chemistry*, 6, 269 – 275.

Laven, R.A., Cuttance, E.L., Yang, D.A., & Mason WA (2021). The prevalence of gross pathological damage in the livers of dairy cattle at processing plants in autumn in the North Island of New Zealand and an assessment of the gross liver pathology score as a method for estimating the prevalence of facial eczema. *New Zealand Veterinary Journal*, 69(2), 113–120.

Lubran, M. M. (1978).The measurement of serum proteins by Biuret method. Annals of *Clinical Laboratory Science*, 8(2): 106-110.

Mellau, L.S.B., Nonga, H.E., & Karimuribo, E.D. (2010). A slaughter house survey of liver lesions in slaughtered cattle, sheep and goats at Arusha Tanzania. *Research Journal of Veterinary Sciences*, 3(3), 179 – 188.

Nicole, W. (2017). CAFOs and Environmental Justice: The Case of North Carolina. *Environmental Health Perspectives. 121 (6), a182–a189.*

Nwachukwu, C.U., & Udegbunam, C. (2020). Rural population and pork consumption in Imo State, Nigeria. Nigerian Journal of Animal Science, 22 (1), 165-185

Nwokediuko, S.C., Osuala, P.C., Uduma, U.V., Alaneme, A.K., Onwuka, C.C., & Mesigo, C. (2013) Pattern of liver diseases admissions in a Nigerian tertiary hospital. *Nigerian Journal of Clinical Practice*, 16(3), 339 – 342.

Passmore, R., & Eastwood, M.A. (1986) *Human Nutrition and Dietetics*, Churchill Livingstone

Pathiraja, N. 1986. Improvement of pig production in developing countries. 1. Exploitation of hybrid vigour (heterosis). *World Animal Review*, 60, 18-25.

Pratt, D. S., & Kaplan, M. M. (2000). Evaluation of abnormal liver-enzyme results in asymptomatic patients. *New England Journal of Medicine* 342, 1266-1271

Price, J. F., & Schweigert, B.S. (1971). The Science of Meat and Meat Products, 2nd ed. Pp 275-279

Radostits, O.M., Gay, C.C., Blood, D.C., & Hincliff, K.W. (2000) Veterinay Medicine 9th Edition. Saunder London pp 1819-1822

Reitman, S., & Frankel, S. (1957), A colorimetric method for determination of serum glutamic oxaloacetic and glutamic pyruvic transaminases. *American Journal of Clinical Pathology*. 28, 56 – 62.

Rifai, N., Warnick, G.R., & Remaley, A.T. (2008) Analysis of lipids, lipoproteins and apolipoproteins. In: Burtis CA, Ashwood ER &Bruns DE (Eds.), Tietz Fundamentals of Clinical Chemistry. 6th ed. Saunders Elsevier, Missouri, pp 422 - 427.

Setiawan, V.W., Stram, D.O., Porcel, J., Lu, S.C., Marchand, L.L., & Noureddin, M. (2016) Prevalence of chronic liver disease and cirrhosis by underlying cause in understudied ethnic groups: the multiethnic cohort. *Hepatology*, 64(6), 1969 – 1977.

Soulsby, E.J.L., (1968). Helminths, Arthropods and Protozoa of Domestic Animals, 6thed. (Bailliere, Tindall and Cassell, London).

Thawley, V. (2017). Acute liver injury and failure. *Veterinary Clinics: Small Animal Practice*, 47(3), 617 – 630.

Watson, P. J., Roulois, A. J., Scase, T. J., Irvine, R., & Herrtage, M. E. (2010). Prevalence of hepatic lesions at post-mortem examination in dogs and association with pancreatitis. *The Journal of Small Animal Practice*, *51*(11), 566–572.