Results & Discussion

4. RESULTS AND DISCUSSION

4.1. Water balance in starch production process

As mentioned before, for water auditing in starch factory throughout the different manufacture processes, the quantities of water intake consumption was recorded through water meter which is installed in each process. Also, the quantities of discharged wastewater were recorded according to the flow rate of wastewater for each process by using basket and stop watch.

Table (20) showed that; the average water consumption in starch factory was 555 m^3/ day. Wet cleaning, soaking, washing, screen milling and first centrifuge processes were consumed 12 - 15 – 8 – 115 and 325 m^3/ day respectively.

Water consumption in production process was 55.5 m^3/ ton broken rice, 4.5 times higher than the standard norms (8-12) m^3 water / ton of raw broken rice (Brault, 1991) [(102)].

Results showed that first centrifuge process was consumed the highest consumption of water about 58.56 % from the total consumption. About 300 m^3/ day of centrifuge water used to cool it when starch milk stopped feeding until refeeding again.

Table (21) showed that; the average of daily amounts of wastewater generated from the various processes of starch production was 490 m^3/ day. Wet cleaning, soaking, washing, screen milling and first centrifuge processes were discharged 11 - 13 – 7 – 0.1 and 450 m^3/ day respectively (Appendix 2.a, b, c, d).

Results showed that first centrifuge process was discharged the highest wastewater about 91.83 % from the total wastewater.

Wastewater from first centrifuge process divided into clean water (300 m^3/ day) and wastewater (150 m^3/ day), the first was discharged when starch milk stopped feeding to the centrifuge and other wastewater contained highly organic waste from centrifuge process.

Table (20): Water consumption per day in starch manufacturing process

Process	Average of water consumption m^3 / Day	%
Wet cleaning	12	2.16
Soaking	15	2.70
Washing	8	1.44
Alkali water treatment	8	1.44
Milling	23	4.14
Screens milled	115	20.72
First centrifuge	325	58.56
2^{nd} centrifuge	5	0.90
Clean tools and floor	4	0.72
Feed boiler	40	7.21
Total	555	100

Table (21): Wastewater generation from starch manufacture process

Process	Average of wastewater generation m^3/day		%
Wet cleaning	11		2.24
Soaking	13		2.65
Washing	7		1.43
Screen milling	0.1		0.02
First centrifugal	Clean water	300	91.83
	Wastewater	150	
Second centrifugal	4		0.82
Clean tools and floors	4		0.82
Total	490		100

From the water balance of the plant during the research period, there was a lot of water loses as a result of the following reasons:

- Lower production rates for the maximum capacity
- Not re-use cooling water
- Not use sprays water under pressure in the washing and wet cleaning processes
- Lack of steam traps on steam lines
- Water leaking from valves

Recycling of clean water from centrifuge process will decrease about 54.0 % of daily water consumption and 61.22 % of daily wastewater generated.

4.2. Chemical composition of broken rice

Grade zero and one of broken rice are a raw material in starch production in ESYD during the study period.

Results in Table 22 showed that the chemical composition of grade zero was 8.72, 0.74, 1.83, 1.48 and 87.23% while grade one was 8.80, 0.79, 1.92, 1.50 and 86.99% of protein, fat, ash, crude fiber and carbohydrates respectively. From the obtained results there were few differences in the chemical composition between the two grades and the difference was in grain size and amount of impurities.

Hertrampf and Piedad-Pascual (2000) [(100)] found that broken rice is relatively low in crude protein compared to rice bran, and lower in crude protein, fat and crude fiber than in rice polishing.

Doma (1970) [(99)] state that the composition of broken rice (grade zero), as percentages of dry matter, are 9.5%, 0.56%, 1.15%, 1.05 and 87.2% and grade one are: 10.2, 0.6, 1.13, 1.1 and 86.38% for protein, ether, ash, crude fiber, and carbohydrates respectively.

On the other hand, Dahab (2006) [(101)] found that the composition of broken rice are 7.68% protein, 0.7% fats, 0.27% crude fibers, 0.36% ash, and 90.81% carbohydrates.

Table (22): Chemical composition of broken rice flour (grade zero & grade one)

Parameters Chemical composition*	Chemical composition*of grade zero (%)	Chemical composition* of grade one (%)
Protein	8.72	8.80
Crude fat	0.74	0.79
Ash	1.83	1.92
Crude fiber	1.48	1.50
Carbohydrates**	87.23	86.99
Moisture content	11.89	11.79

* As dry weight.
** Available carbohydrate by difference.

4.3. Results of analysis of rice starch manufacture wastewater

As mentioned before wastewater samples were collected from 5 points in the starch manufacture process and from settling tank before settling. These five discharge points are:

1. Wet cleaning wastewater
2. Soaking wastewater
3. Washing wastewater
4. First centrifugal wastewater
5. Screen milling wastewater

Several parameters were studied to identify the character and composition of wastewater as: pH, temperature, TS, TSS, TDS, COD, BOD, crude protein content, crude fat, total ash, crude fiber, carbohydrate contents, and sodium chloride.

4.3.1. pH

Results in Table (23) showed the pH of wastewater in the six sampling points in the starch production processes during the research period. The results indicated that there was a variation in the pH of the wastewater from the production processes which was in average of 6.48, 4.47, 5.80, 9.61 and 7.8 to wet cleaning, soaking, washing, first centrifuge and screen milling processes respectively and it was 8.2 in settling tank before settling.

Results indicated that the higher wastewater pH was from first centrifuge process because of adding diluted sodium hydroxide solution in the previous stages (soaking - milling) but the lower wastewater pH was from soaking process because of longer soaking time ,which may cause fermentation.

The pH of soaking, washing and first centrifugal processes is not compatible with Egyptian Environmental Legal Requirements for Industrial Wastewater (from pH 6-9) but it is compatible with wet cleaning, screen milling processes add to the wastewater in settling tank.

Nasr *et al*. (2013) [165] reported that starch manufacturing factories discharge huge amount of wastewater which rich in biodegradable organic matter and the wastewater pH was 6.86.

Kumar and Gidde (2014) [166] found that pH in parboiled rice mill effluent, was 5.32

Tawfik *et al.* (2013) [167] reported that the pH of corn starch manufacture waste water was 7.2 in average.

Table (23): pH of wastewater in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	6.23	6.00	6.84	6.68	6.58	6.56	6.48
2.Soaking wastewater	4.14	4.60	4.30	4.62	4.48	4.70	4.47
3.Washing wastewater	5.88	5.94	6.02	5.47	5.68	5.80	5.80
4.First centrifugal wastewater	9.68	9.68	9.63	9.88	9.40	9.39	9.61
5.Screen milling wastewater	7.50	7.73	8.15	7.38	8.00	8.04	7.80
6.Settling tank	7.92	8.22	8.31	8.15	8.33	8.27	8.2

4.3.2. Temperature

The temperature of wastewater in different sampling sites is represented in Table 24. The average temperatures were 25, 23.9, 24.3, 30.55 and 25 °C to wet cleaning, soaking, washing, first centrifuge and screen milling processes respectively and it was 28 in settling tank. It was found that the highest wastewater temperature was from first centrifuge process because of the impact of centrifuge machine movement but the lowest temperature was in soaking wastewater because of longer soaking period away from heat sources, it was also noted that the seasons affect on wastewater temperature especially in winter and summer months, Appendix 1, where the temperature reach to higher and lower degree respectively. Temperatures of the wastewater from production processes are compatible with Egyptian Environmental Legal Requirements for Industrial Wastewater which is 35 ^{0} C as maximum degree.

Table (24): Temperature of waste water in the different sampling sites (^{0} C)

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning waste water	24	27	26	24	26	25	25
2.Soaking waste water	23	24	25	24.5	23	24	23.9
3.Washing wastewater	22	25	26	25	23	25	24.3
4.First centrifugal waste water	28	30	32	31	31	31	30.55
5.Screen milling waste water	25	25.5	24.5	25.5	23.5	26	25
6.Settling tank	27.5	28	27	29	29.5	27	28

4.3.3. Total solids

As shown in Table 25, total solids were in average of 30041, 44719, 11145, 8210, 236164 and 56218 mg/l to wet cleaning, soaking, washing, first centrifuge and screen milling processes concentrate and dilution respectively and it was 12385 mg/l in settling tank before settling. The highly total solids contents was in screen milling wastewater which was 236164 mg /l in concentrate wastewater and 56218 mg/l in screen milling wastewater after dilution and the lower total solids content was in first centrifuge wastewater which was 8210 mg/l. It was clear that the effluent from production processes contain high loads of total solids.

Doma (1970) [99] found that the total solids in soaking wastewater was in average 73800 mg/l and in first centrifugal effluent was 54200 mg/l.

Kumar and Gidde (2014) [166] found that total solids (TS) in parboiled rice mill effluent, was 4446 mg/l.

Compared with other starch production process, the total solids content in the effluent of wheat starch production were 1.2-3.0% (Harris, 1986) [168], 1.3 – 2.5% (Jin *et al* 1999)[169] and 1.28 – 2.48 (Pidgeon, 2008)[170].

Table (25): Total solids (mg/l) in waste water in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	32105	32484	29114	29878	28807	27860	30041
2.Soaking wastewater	44178	44430	40800	45800	46548	46559	44719
3.Washing wastewater	11328	10988	11222	11077	11100	11155	11145
4.First centrifugal wastewater	7540	8199	8055	8645	8002	8819	8210
5.Screen milling wastewater							
a. Concentrate	244122	229111	242324	229145	236164	236118	236164
b. Dilute	58113	54539	57684	54547	56218	56207	56218
6.Settling tank	12559	12485	12442	12247	12378	12199	12385

4.3.4. Total suspended solids

Table 26 showed that the average values of the total suspended solids; 20519, 28842, 6690, 3285, 229214 and 54229 mg/ l in the wet cleaning, soaking, washing, first centrifuge and screen milling processes concentrate and dilution respectively and it was 6356 mg/l in settling tank before settling. The results indicated that the highly total suspended solids contents was in screen milling wastewater which recorded 229214 mg /l in concentrate wastewater and 54229 mg/l in screen milling wastewater after dilution and the lower suspended solids content was in first centrifuge wastewater 3285 mg/l.

It was observed that the effluent from production processes contain highly suspended solids and this corresponds with other food processing wastes which have higher levels of organic matter and suspended solids (Kroyer, 1995)[171].

Compared with other rice manufactures such as rice cracker manufacture, the suspended solids of washing rice wastewater was 2868 mg/l (Janesiripanich, 1995) [35] and in others starch production process, the suspended solids content in the effluent of wheat starch production was 1000-8000 mg/l (Harris, 1986) [168], 3500 mg/l (Yanagi, 1994)[172] and 1670-2650 mg/l (Jin *et al.*, 1999)[169].

Kumar and Gidde (2014) [166] found that TSS in parboiled rice mill effluent, was 1808 mg/l.

Hein *et al*. (1999) [173] found that tapioca starch production wastewater contains 200-7,600 mg/l. Tawfik *et al.* (2013)[167] found that TSS in corn starch production wastewater was from 230 to 8648 mg/l.

Table (26): Total suspended solids (mg/l) in wastewater in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	21299	21726	20290	20699	19869	19232	20519
2.Soaking wastewater	28845	29067	26212	29354	29779	29795	28842
3.Washing wastewater	6800	6596	6736	6649	6663	6696	6690
4.First centrifugal wastewater	3170	3375	3362	3195	3383	3225	3285
5.Screen milling wastewater							
a. Concentrate	236937	222368	235239	222337	229214	229189	229214
b. Dilute	56056	52610	55654	52602	54229	54223	54229
6.Settling tank	6465	6259	6208	6369	6410	6424	6356

4.3.5. Total dissolved solids

The average values of total dissolved solids contents shown in Table 27. Total dissolved solids were 9522, 15877, 4455, 4925, 6950 and 1989 mg/ l to wet cleaning, soaking, washing, first centrifuge and screen milling processes concentrate and dilution respectively and it was 6029 mg/l in settling tank. The highly total dissolved solids contents was in soaking wastewater; 15877 mg /l and the lowest in dilution screen milling wastewater; 1989 mg/l.

Kumar and Gidde (2014) [166] found that dissolved solids in parboiled rice mill effluent, was 2638 mg/l.

Table (27): Total dissolved solids (mg/l) in wastewater in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	10806	10758	8824	9179	8938	8628	9522
2.Soaking wastewater	15333	15363	14588	16446	16769	16764	15877
3.Washing wastewater	4528	4392	4486	4428	4437	4459	4455
4.First centrifugal wastewater	4370	4824	4693	5450	4619	5594	4925
5.Screen milling wastewater							
a. Concentrate	7485	6743	7463	6808	6672	6529	6950
b. Dilute	2057	1929	2030	1945	1989	1984	1989
6.Settling tank	6094	6226	6234	5878	5968	5775	6029

4.3.6. Chemical oxygen demand (COD)

Results in Table 28 showed that the chemical oxygen demand (COD) of wastewater from the production processes in average 18000, 24400, 7200, 5850, 62560 and 28254 mg/l to wet cleaning, soaking, washing, first centrifuge and screen milling processes concentrate and dilution respectively and it was 8000 mg/l in settling tank before settling.

The highly chemical oxygen demand was in concentration screen milling wastewater; 62560 mg /l and the lowest in the first centrifugal wastewater; 5850 mg/l.

It was obvious that the effluent from production processes contain highly COD and this corresponds with other food processing wastes which have higher levels of COD (Kroyer, 1995) (171).

Jin *et al*. (2002) (37) stated that (COD) levels of starch industry wastewater range from 10 to 30 g/L.

In other rice manufactures, such as rice cracker manufacture, the COD of washing wastewater was 13031.4 mg/l (Janesiripanich, 1995) (35) and in parboiled rice mill effluent was 5644 mg/l (Kumar and Gidde, 2014) (166)

In other starch production process, the COD in the effluent of wheat starch production was 18000 mg/l (Yanagi *et al*., 1994) (172), 11970-18900 mg/l (Jin *et al.*, 1999) (169) and 11870-18200 mg/l (Pidgeon, 2008) (170).

Hien *et al*. (1999) (173) found that COD of wastewater from tapioca production processes containing 11,000-13,500 mg/l but Oanh *et al*. (2001) (174) and Mai *et al.* (2001) (175) found that a total COD was in the range of 7,000-41,406 mg/l in tapioca starch production wastewater.

Nasr *et al*. (2013) (165) found that starch manufacturing factories discharge huge amount of wastewater rich in biodegradable organic matter and COD of the wastewater was 1.8 g/l. Tawfik *et al.* (2013) (167) found that COD in corn starch production wastewater ranged from 6270 to 38835 mg/l.

Table (28) COD (mg/l) in wastewater in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	19095	19325	17489	18000	17304	16789	18000
2.Soaking wastewater	23999	24100	21995	24924	25678	25704	24400
3.Washing wastewater	7318	7099	7250	7156	7171	7206	7200
4.First centrifugal wastewater	5290	5899	5790	6066	5740	6315	5850
5.Screen milling wastewater							
a. Concentrate	64668	60692	64192	60701	62560	62548	62560
b. Dilute	29206	27410	28991	27414	28254	28249	28254
6.Settling tank	7828	8130	7946	8079	8034	7983	8000

4.3.7. Biological oxygen demand (BOD)

The average values of BOD are represented in Table 29; these values were 12000, 16266, 4800, 3900, 31706 and 18534 mg/l to wet cleaning, soaking, washing, first centrifuge and screen milling processes concentrate and dilution respectively and it was 5400 mg/l in settling tank before settling.

The results showed that the highly biological oxygen demand was in concentration screen milling wastewater; 31706 mg /l and the lowest value was in first centrifugal wastewater; 3900 mg/l.

It was found that the effluent from production processes contain highly BOD and this corresponds with other food processing wastes which have higher levels of BOD (Kroyer, 1995) [171].

In other starch production process, the BOD_5 in the effluent of tapioca starch production ranged from 6,200-23,077 mg/l, Mai *et al*. (2011) [175] and Oanh *et al.* (2001) [174]. Tawfik *et al.* (2013) [167] found that BOD_5 in corn starch production wastewater ranged from 3825 to 21748 mg/l.

Table (29): BOD (mg/l) in wastewater in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	12600	12779	11737	12000	11594	11290	12000
2.Soaking wastewater	16125	16283	14562	16495	17059	17072	16266
3.Washing wastewater	4879	4733	4833	4771	4781	4804	4800
4.First centrifugal wastewater	3550	3925	3845	4140	3790	4150	3900
5.Screen milling wastewater							
a. Concentrate	32774	30759	32533	30764	31706	31700	31706
b. dilute	19158	17980	19017	17983	18534	18530	18534
6- Settling tank	5322	5459	5375	5436	5416	5392	5400

4.3.8. Crude protein

Crude protein content in wastewater from the production processes in different sampling sites represented in Table 30 which in average of 0.640, 1.565, 0.312, 0.347, 2.72 and 0.646 gm/l00ml to wet cleaning, soaking, washing, first centrifuge and screen milling processes concentrate and dilution, respectively and it was 0.452 in settling tank before settling .

The highly ratio of crude protein to total solids content was in first centrifugal wastewater; 42.27% and the lowest ratio was in screen milling wastewater; 11.50%.

Doma (1970) [99] found that the effluent from soaking and first centrifugal processes contain 3.090 and 0.930 g /100ml of protein respectively. Harris (1986) [168] found that the effluent of wheat starch production contains 0.25-0.44% proteins from the total solids.

Mironescu (2011) [176] found that potato starch production wastewater contains 0.70% of protein. Nasr *et al*. (2013) [165] stated that starch manufacturing factories discharge huge amount of wastewater which rich in biodegradable organic matter and contains 60 mg/l of proteins.

Table (30): Crude protein content (g/100ml) in wastewater in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	0.668	0.654	0.612	0.619	0.648	0.641	0.640
2.Soaking wastewater	1.612	1.504	1.425	1.529	1.651	1.669	1.565
3.Washing wastewater	0.320	0.319	0.300	0.305	0.299	0. 329	0.312
4.First centrifugal wastewater	0.262	0.346	0.324	0.391	0.340	0.419	0.347
5.Screen milling wastewater							
a. Concentrate	2.749	2.717	2.700	2.721	2.742	2.691	2.72
b. Dilute	0.654	0.645	0.641	0.646	0.651	0.639	0.646
6.Settling tank	0.464	0.431	0.442	0.450	0.464	0.461	0.452

4.3.9. Crude fat

The crude fat content in wastewater from the production processes represented, 0.147, 0.092, 0.015, 0.010, 0.16 and 0.039 g/l00ml to wet cleaning, soaking, washing, first centrifuge and screen milling processes concentrate and dilution respectively and it was 0.033 in settling tank before settling (Table 31).

The highly ratio of crude fat to total solids content was in wet cleaning wastewater; 4.9% and the lowest ratio was in screen milling waste water; 0.69%.

Doma (1970) [(99)] found that ether extract in the effluent from soaking and first centrifugal processes contains 0.004 and 0.002 g/100ml of the effluent respectively.

Table (31): Crude fat content (g/100ml) in wastewater in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	0.149	0.151	0.139	0.152	0.158	0.134	0.147
2.Soaking wastewater	0.089	0.088	0.099	0.098	0.090	0.088	0.092
3.Washing wastewater	0.018	0.015	0.017	0.014	0.013	0. 013	0.015
4.First centrifugal wastewater	0.010	0.012	0.009	0.010	0.010	0.009	0.010
5.Screen milling wastewater							
a. Concentrate	0.157	0.176	0.171	0.173	0.136	0.147	0.160
b. Dilute	0.039	0.042	0.042	0.042	0.033	0.036	0.039
6.Settling tank	0.037	0.035	0.025	0.036	0.028	0.038	0.033

4.3.10. Crude fiber

The average values of crude fiber content in wastewater from the production processes presented in Table 32, which in average of 0.206, 0.300, 0.075, 0.049, 3.48 and 0.590 gm/l00ml for wet cleaning, soaking, washing, first centrifuge and screen milling processes concentrate and dilution respectively and it was 0.080 in settling tank.

The highly ratio of crude fiber to total solids content was in screen milling wastewater; 10.50% and the lowest ratio was in first centrifugal wastewater; 5.97%.

Doma (1970) [99] found that crude fiber in the effluent from soaking and first centrifugal processes contains 0.790 and 0.650 gm/100ml of the effluent respectively.

Table (32): Crude fiber content (g/100ml) in wastewater in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	0.221	0.198	0.189	0.215	0.213	0.200	0.206
2.Soaking wastewater	0.319	0.302	0.297	0.298	0.286	0.298	0.300
3.Washing wastewater	0.071	0.065	0.078	0.075	0.080	0. 081	0.075
4. First centrifugal wastewater	0.049	0.043	0.052	0.059	0.049	0.042	0.049
5.Screen milling wastewater							
a. Concentrate	3.477	3.458	3.503	3.452	3.499	3.491	3.480
b. Dilute	0.599	0.590	0.596	0.585	0.591	0.579	0.590
6.Settling tank	0.078	0.082	0.074	0.086	0.089	0.071	0.080

4.3.11. Ash

Table 33 showed the ash content in wastewater from the production processes in average of 0.199, 0.288, 0.069, 0.041, 1.910 and 0.399 g/l00ml for wet cleaning, soaking, washing, first centrifuge and screen milling processes concentrate and dilution respectively and it was 0.071 in settling tank before settling.

The highly ratio of ash to total solids content was in screen milling wastewater; 7.10% and the lowest ratio was in first centrifugal wastewater; 4.99%.

Doma (1970) [99] found that ash in the effluent from soaking and first centrifugal processes were 1.460 and 1.380 gm/100ml of the effluent respectively.

In other starch manufacture, Mironescu (2011) [176] found that potato starch production wastewater contains 0.70% protein and 0.153% ash.

Table (33): Ash content (g/100ml) in wastewater in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	0.190	0.187	0.205	0.205	0.201	0.208	0.199
2.Soaking wastewater	0.291	0.301	0.301	0.275	0.289	0.271	0.288
3.Washing wastewater	0.076	0.065	0.062	0.075	0.067	0. 069	0.069
4. First centrifugal wastewater	0.034	0.039	0.040	0.046	0.038	0.049	0.041
5.Screen milling wastewater							
a. Concentrate	1.99	1.79	2.03	1.85	1.87	1.95	1.91
b. Dilute	0.402	0.402	0.411	0.390	0.396	0.393	0.399
6.Settling tank	0.063	0.080	0.067	0.069	0.081	0.066	0.071

4.3.12. Total carbohydrates

Table 34, showed that the total carbohydrates content in wastewater from the production processes in average of 1.808, 2.227, 0.643, 0.374, 15.343 and 3.947 g/l00ml for wet cleaning, soaking, washing, first centrifuge and screen milling processes concentrate and dilution respectively and it was 1.098 in settling tank.

The highly ratio of carbohydrates to total solids content was in screen milling wastewater; 68.24% and the lowest ratio was in first centrifugal wastewater; 44.33%.

Nasr *et al*. (2013) [165] found that starch manufacturing factories discharge huge amount of wastewater which rich in biodegradable organic matter and contains 1.6 g/l of total carbohydrates.

Table (34): Total carbohydrates content (g/100ml) in wastewater in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	1.982	1.720	1.755	1.789	1.890	1.707	1.808
2.Soaking wastewater	2.107	2.248	1.958	2.380	2.339	2.330	2.227
3.Washing wastewater	0.647	0.635	0.665	0.639	0.650	0.624	0.643
4.First centrifugal wastewater	0.399	0.379	0.380	0.358	0.363	0.362	0.374
5.Screen milling wastewater							
a. Concentrate	16.039	14.770	15.828	14.719	15.369	15.333	15.343
b. Dilute	4.117	3.775	4.075	3.792	3.951	3.974	3.947
6.Settling tank	0.614	0.621	0.636	0.600	0.563	0.584	0.603

4.3.13. Sodium chloride

Sodium chloride content in wastewater from the production processes represented 0.065, 0.099, 0.014, 0.014, 0.465 and 0.105 g / l00 ml for wet cleaning, soaking, washing, first centrifuge and screen milling processes concentrate and dilution respectively and it was 0.024 in settling tank.

The highly ratio of sodium chloride to total solids content was in soaking wastewater; 2.21% and the lowest ratio was in first centrifugal wastewater; 1.22%.

Doma (1970) [99] found that sodium chloride content in the effluent from soaking and first centrifugal processes contains 0.640 and 0.150 g /100 ml of the effluent respectively.

Table (35): Sodium chloride content (g/100ml) in wastewater in the different sampling sites

Site	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
1.Wet cleaning wastewater	0.069	0.065	0.076	0.051	0.065	0.064	0.065
2.Soaking wastewater	0.085	0.095	0.099	0.115	0.103	0.097	0.099
3.Washing wastewater	0.012	0.014	0.013	0.015	0.014	0.016	0.014
4.First centrifugal wastewater	0.012	0.014	0.015	0.014	0.015	0.014	0.014
5.Screen milling wastewater							
a. Concentrate	0.440	0.480	0.483	0.434	0.470	0.482	0.465
b. Dilute	0.105	0.114	0.115	0.099	0.113	0.120	0.111
6.Settling tank	0.023	0.028	0.027	0.024	0.020	0.022	0.024

4.4. Precipitation of soluble proteins

For precipitating soluble proteins, the effect of pH and sedimentation time, on the process was studied. Also, the characterization of wastewater after treatment and the composition of the dry separated solids were investigated.

4.4.1. Effect of pH on precipitation of proteins

There are four kinds of proteins in rice: albumin, globulin, glutelin and prolamin. Most proteins show minimum solubility at their isoelectric point and this principle was used to isolate rice proteins from wastewater by adjusting the pH of wastewater to its isoelectric point.

Wastewater was collected from outlet of production process; the pH was adjusted from 3 to 9 by using sulfuric acid 1N or sodium hydroxide 1N. Table 36 and Figure 17 showed the precipitated proteins at different pH. The results revealed that the highest percent of protein precipitated was 70% from total protein contents at pH 4.5.

The results indicated that there was a compatible between it and Ju *et al.* (2006) [110] who found that the isoelectric points of albumin (pH 4.1), globulin (pH 4.3 and pH 7.9), and glutelin (pH 4.8), at which they were precipitated with 82.3 to 93.2% recovery efficiency and with Doma (1970) [99] who found that the isoelectric point to the rice steeping liquor was at pH 4.5 and the volume of protein precipitate represent 70% from total protein.

Table (36) Effect of pH on proteins (solubility – precipitated)

pH	Volume of H_2SO_4 1N ml /100 ml	Volume of N_aOH 1N ml / 100 ml	%Protein solubility	%Protein precipitated
3.0	1.22	0	40	60
3.5	1.00	0	38	62
4.0	0.76	0	34	66
4.5	0.72	0	**30**	**70**
5.0	0.68	0	35	65
5.5	0.64	0	42	58
6.0	0.60	0	51	49
6.5	0.53	0	59	41
7.0	0.46	0	48	52
7.5	0.38	0	42	48
8.0	0.30	0	62	38
8.5	0	0.02	70	30
9.0	0	0.02	85	15

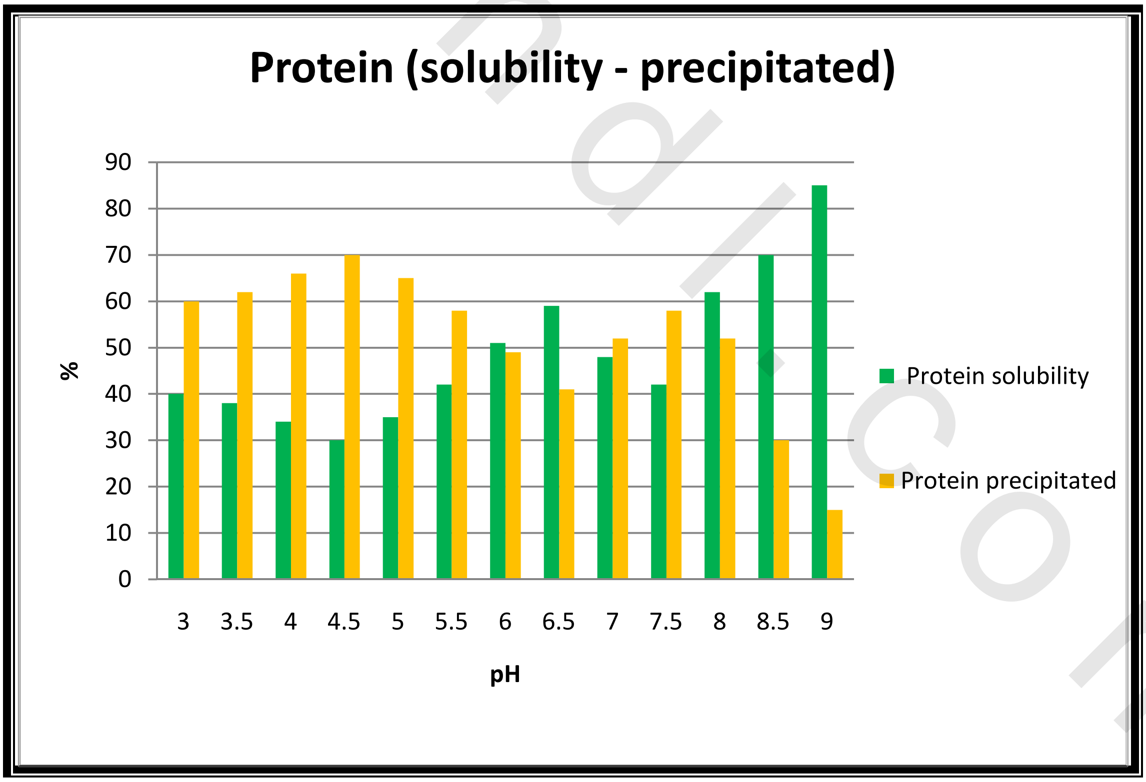

Figure (17): Effect of pH on protein solubility- precipitated of wastewater

4.4.2. Effect of time on sedimentation efficiency

At isoelectric point for rice protein at pH 4.5, the effect of time variation on wastewater characteristics in settling tank as volume of total solids, suspended solids, dissolved solids, removal from wastewater presented in Table 37 and Figure 18.

The highest decrease indicated after 3 h at pH 4.5 which reaches to 80.0, 95.0, and 64.2 % from total, suspended and dissolved solids contents in the sample respectively. The results of supernatant water characteristics showed a decrease in the water content of total suspended and dissolved solids from 12385, 6356 and 6029 mg/l to 2477, 317 and 2160 mg/l respectively compared with its content before treatment.

Table (37): Variation of waste water characteristics at different time

Characteristics of Waste water (mg/liter)	Time (min)								
	0	30	60	90	120	150	180	210	240
Total solids	12385	7250	4900	3500	3200	2695	**2477**	2543	2580
Total suspended	6356	3150	1850	1000	850	500	**317**	328	330
Total dissolved	6029	4100	3050	2500	2350	2195	**2160**	2215	2250

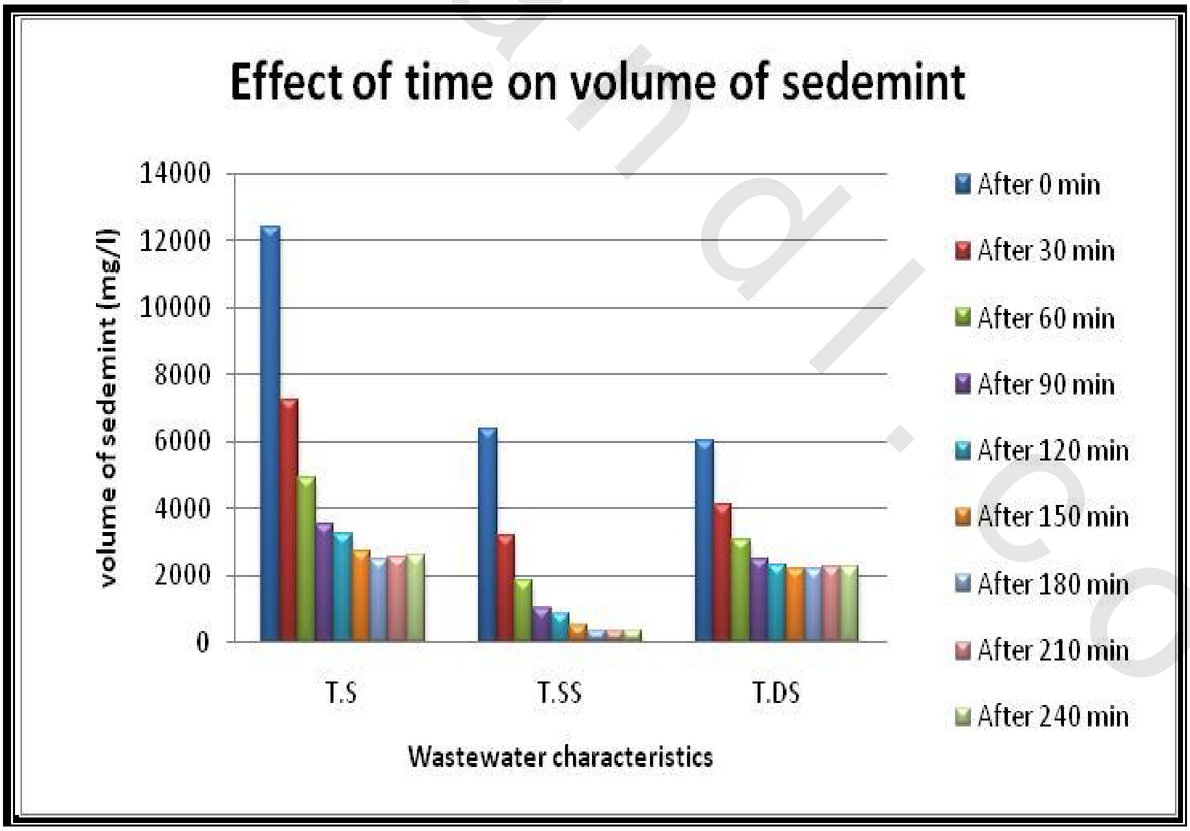

Figure (18): Changing of wastewater characterization with changing time

4.4.3. Characteristics of wastewater after treatment

The characteristics of wastewater changed. Results in Table 38, showed the changing in pH, total solids, suspended, dissolved, COD, BOD in wastewater before and after treatment. The pH decreased from 8.0 to 4.3 because of using sulfuric acid in treatment, total solids, suspended and dissolved decreased from 12385, 6356 and 6029 to 2477, 317 and 2160 mg/l respectively. COD and BOD decreased from 8000 and 5400 to 2400 and 1647 mg/l respectively.

Although the highly changing in wastewater characteristics after removing proteins and other dry matter from wastewater, the characteristics of supernatant wastewater still not suitable with Egyptian environmental legal requirements for industrial wastewater as in appendix1 but recirculation it in other production process will decrease water consumption in this processes as Janesiripanich (1995) [35] who cited that wastewater can be recirculated in wash raw material until wash water reached a contaminate concentration in terms of COD of up to about 40,000 mg/l.

Table (38); Comparison between the characteristics of wastewater before and after treatment

Characteristics of Wastewater	Before treatment	After treatment	% removal
pH	8.0	4.3	-
Total solids (mg/liter)	12385	2477	80.0
Total suspended (mg/liter)	6356	317	95.0
Total dissolved (mg/liter)	6029	2160	64.2
Chemical oxygen demand (mg/liter)	8000	2400	70.0
Biological oxygen demand (mg/liter)	5400	1647	69.5

4.4.4. Chemical composition of dry separated material of wastewater

Centrifuge machine (Model Universal 32 R) (Figure 19) was used at 10000 x g for 20 min to separate proteins and other organic wastes from wastewater, and then the separated was dried by hot air.

Figure (19): Centrifuge machine (Model Universal 32 R)

Several parameters were studied to identify the composition of drying separated material of wastewater from settling tank as: moisture, crude protein, crude fat, crude fiber, ash, total carbohydrates, total phenol content and aflatoxins content in dry separated material.

Table 39, showed that, the dried separated material from settling tank contained 12.0, 16.80, 1.18, 3.38, 6.12 and 60.50% for moisture, crude protein, crude fat, ash, crude fiber and total carbohydrates contents add to 1.49 mg/g grain of total phenol, the results also showed that it was free from aflatoxins.

The result of total phenolic content was agreed with Goffman and Bergman (2004) [88] who found that total phenolic content in whole rice grain was ranging from 0.69 to 2.74 mg gallic acid/g grain and with Tian *et al*. (2004) [89] who reported that total soluble phenolic acid contents in white, brown and germinated brown rice were 0.28, 2.17 and 1.45 mg/100 g flour, respectively.

Table (39): Chemical composition of dry separated material from settling tank

Parameter	%
Moisture	12.00
Crude protein	16.80
Crude fat	1.18
Ash	3.38
Crude fiber	6.12
Total carbohydrate	60.50
Total phenol	1.49 *
Aflatoxin content	free

* as mg/g

4.4.5. Expected production quantities of the new by-product

Results in Table 40 showed that the amount of wastewater discharged from the various manufacturing process at current (10 ton broken rice / day) and maximum (50 ton broken rice / day) of operating rate capacity and its content of total solids while Table 41 showed that the expected production quantities (kg/day) of dried separated material as new rice starch manufacture by-product (RSMBP) in rice starch plant at extracted ratio 80.0 % at current and maximum operating rate capacity. Results revealed that the starch plant can produce 1794 and 8970 kg / day of new by-product at current and maximum operating rates respectively, this will raising the economic returns for the company.

Table (40): Amounts of wastewater discharged at current and maximum capacity operating rate

Process	At current operating rate (10 ton broken rice/day) m^3/day	At maximum operating rate (50 ton broken rice /day) m^3/day	T.S mg/l
Wet cleaning	11	55	3
Soaking	13	65	4.47
Washing	7	35	1.11
Screen milling	0.1	0.5	23.6
Centrifugation	150	750	0.82
Total	181.1	905.5	1.24

Table (41): Expected production quantities of the new by-product

Process	At current operating rate Kg/day	At maximum operating rate Kg/day
Wet cleaning	264	1320
Soaking	465	2324
Washing	62	310
Screen milling	19	95
Centrifugation	984	4920
Total	1794	8970

4.5. Biological evaluation

4.5.1. Chemical analysis of experimental diets

The control diet is composed of 40% yellow corn, 36% wheat bran, 15% soybean meal, 6% molasses, 1.0% salt, 1.5% limestone, and 0.5% (premix) essential multivitamins and salts additives while the first treatment diet (T1) is composed from the same ingredients with addition of 5% of dried RSMBP. The second treatment diet (T2) is composed also from the same ingredients with addition of 10% of dried RSMBP. The third treatment diet (T3) is composed from the same ingredients with addition of 20% of dried RSMBP as in Table 42.

The dry matter components were 89.34, 89.38, 89.42 and 89.48% of diet for control, T1, T2 and T3 respectively. The basic chemical analysis of the diets calculated to percent on dry matter were, organic matter percent; 93.71, 93.81, 93.78 and 93.83, organic protein percent; 14.41, 14.34, 14.39 and 14.55, crude fiber percent; 6.48, 6.20, 6.18 and 5.92, ether extract percent; 3.24, 3.26, 3.23 and 3.21, and ash percent; 6.29, 6.19, 6.22 and 6.17 for control, T1, T2 and T3 respectively. Calculated nitrogen free extract; 58.92, 59.38, 59.39 and 59.63, and calculated neutral detergent fibers were 32.55, 32.37, 32.35 and 32.18. Gross energy for treatment rations were 16.25. 16.27, 16.27 and 16.19 mega-joule per kilogram dry matter, while the digestible energy were 2.76, 2.77, 2.77 and 2.78 kilo-calorie per kilogram for control, T1, T2 and T3 respectively, (Table: 42).

Table (42): Composition and chemical analysis of experimental diets (Control, 5, 10 and 20%) for rats during the experimental period

Ingredients	Control (%)	T1 (5%)	T2 (10%)	T3 (20 %)
Yellow corn	40	40	37	33.5
Wheat bran	36	32	31	26
Soybean meal	15	14	13	11.5
Molasses	6.0	6.0	6.0	6.0
Salt	1.0	1.0	1.0	1.0
Limestone	1.5	1.5	1.5	1.5
Premix	0.5	0.5	0.5	0.5
Rice starch by-product	0	5.0	10.	20
Total	100	100	100	100
Chemical analysis (% on DM)				
Dry Matter	89.34	89.38	89.42	89.48
Organic Matter [a]	93.71	93.81	93.78	93.83
Crude protein (%)	14.41	14.34	14.39	14.55
Crude fiber (%)	6.48	6.20	6.18	5.92
Ether Extract	3.24	3.26	3.23	3.21
Nitrogen Free Extract % [b]	58.92	59.38	59.39	59.63
Ash (%)	6.29	6.19	6.22	6.17
Gross Energy Mj/kg DM [c]	16.25	16.27	16.27	16.29
Digestible Energy kcal/kg [d]	2.76	2.77	2.77	2.78
Neutral Detergent Fiber [e]	32.55	32.37	32.35	32.18

a) Organic matter (OM) calculated according to AOAC (1998) [142] OM% = 100-Ash%
b) Nitrogen Free Extract % (NFE%) calculated according to AOAC (1998)[142] NFE% = 100 – (Water%+ CP% + CF% + EE% + Ash%)
c) Gross energy (GE) calculated according to MAFF (1975) [143] GE MJ/kg DM = 0.0226 CP + 0.0407 EE + 0.0192 CF + 0.0177 NFE.
d) Digestible Energy (DE) kcal/kg calculated according to AOAC (1998)[142] DE = 4.36 – 0.0491 X NDF%
e) Neutral Detergent Fiber % (NDF%) calculated according to AOAC (1998)[142] NDF% = 28.294 + 0.657 X CF%

4.5.2. Effect of treatments with 5, 10 and 20% of rice starch manufacture by-product (RSMBP) on body weight gain (BWG), body weight gain ratio (BWGR), feed intake (FI), water intake (WI) and feed efficiency ratio (FER)

Treatment of rats with 5, 10 and 20% of rice starch manufacture by-product revealed insignificant effect on body weight gain, feed efficiency ratio and water intake (Table 43, Figures 20, 23 and 24). Meanwhile a significant increase was observed for body weight gain ratio in all treated groups compared to the control group (Table 43, Figure 21). On the other hand a significant decrease in feed intake was obtained in all treated groups compared to the control group (Table 43, Figure 22).

Sharif (2009) [177] found a significant increase in body weight gain, feed and water intake in rats fed on diet contains rice bran oil as rice industrial by-product compared with rats fed on control diet.

Li *et al*. (2010) [178] found no significant effect in body weight gain and feed efficiency in rats fed control diet and others fed on diet contains brown rice, rice bran, and polished rice.

Mesomya *et al*. (2012) [179] found no significant differences in growth rate between rats fed on control diet and others fed on diets contain both organic and conventional rice.

Yang *et al*. (2012) [180] reported that diets contain rice proteins extracted from *Oryza sativa L*. by extraction method with alkaline followed by precipitation with acidic solution (RP-A) and other by rice protein isolation by starch degradation using a heat stable α –amylase (RP-A) compared with control diet contains casein protein (CAS). Body weight gain of growing rats were significantly reduced by 17.39% in RP-A and by 19.37% in RP-E, respectively, as compared with CAS ($P < 0.05$). No significant difference of gains in body weight was found in RP-A and RP-E ($P > 0.05$). Food intake was not significantly different among groups.

Ahmed *et al*. (2007)[181] found no significant effect in feed efficiency ratio (FER) between rats fed on control diet and others fed on diet containing 5 and 10% rice bran as rice milling industrial by-product.

Um *et al*. (2013) [182] found no significant differences in body weight, food intake and food efficiency ratio between rats fed on diet contained high cholesterol diet with rice protein and other fed on control diet.

Table (43): Effect of treatment with 5, 10 and 20 % rice starch manufacture by-product on digestion parameters

Treatment	Control	Treatments		
		5%	10%	20%
BWG (g/8week)	166.50 ± 8.82	167.60 ± 10.15	149.50 ± 5.65	62.00 ± 7.76
BWGR (%)	88.70 ± 5.14^{b}	114.49 ± 8.08^{a}	108.61 ± 4.35^{a}	116.71 ± 4.65^{a}
Total FI (g/8week)	1421.28 ±30.17^{a}	1333.92± 57.19^{ab}	1244.88 ± 47.04^{b}	1231.44 ± 50.72^{b}
FER	11.72 ± 2.64	12.56 ± 2.30	12.01 ± 2.19	13.16 ± 2.67
Total WI (ml/8week)	2014.88 ± 45.95	2056.32 ± 89.99	1939.28 ±106.97	1980.16± 76.08

Values are expressed as Means ± S.E n=10

^{a,b} Means in a row with superscripts without a common letter differ, $P < 0.05$.

BWG : body weight gain

BWGR: body weight gain ratio

FI : feed intake

FER : feed efficiency ratio

WI : water intake

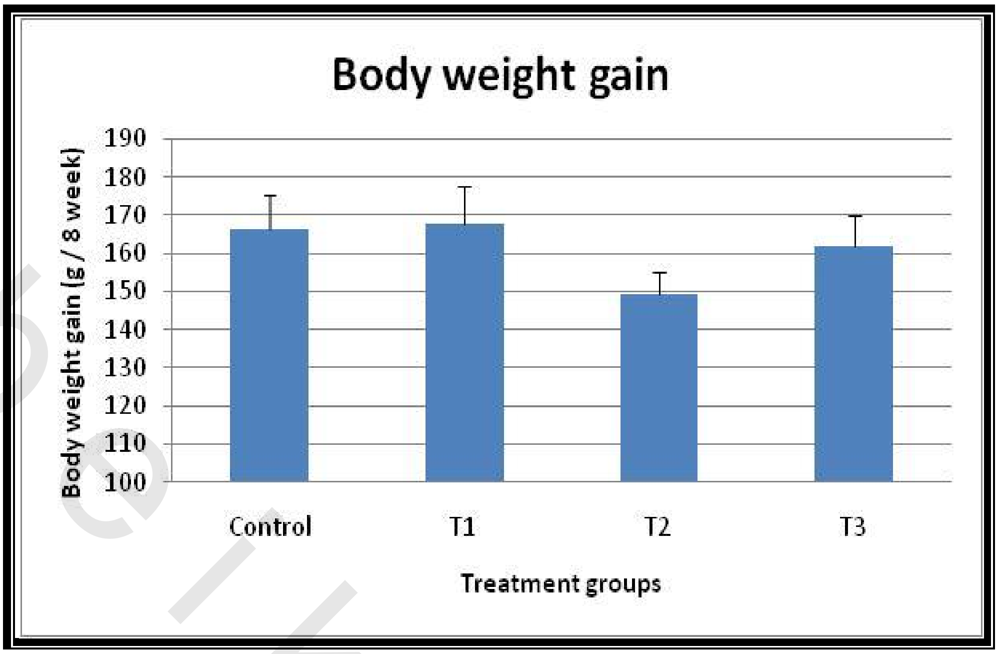

Figure (20): Effect of treatment with 5, 10 and 20 % rice starch manufacture by-product on body weight gain

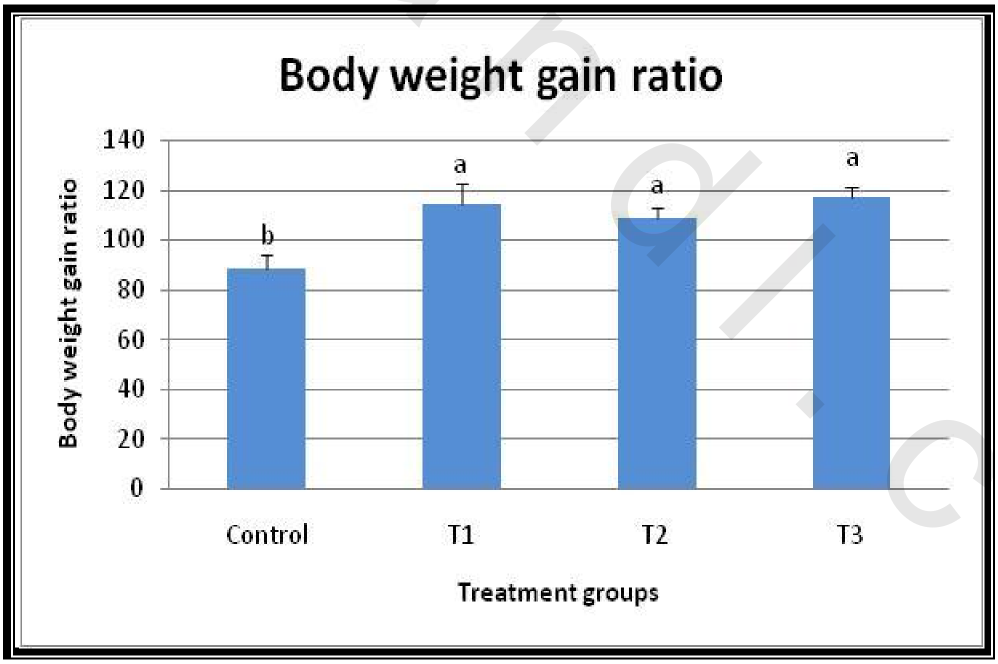

Figure (21): Effect of treatment with 5, 10 and 20 % rice starch manufacture by-product on body weight gain ratio

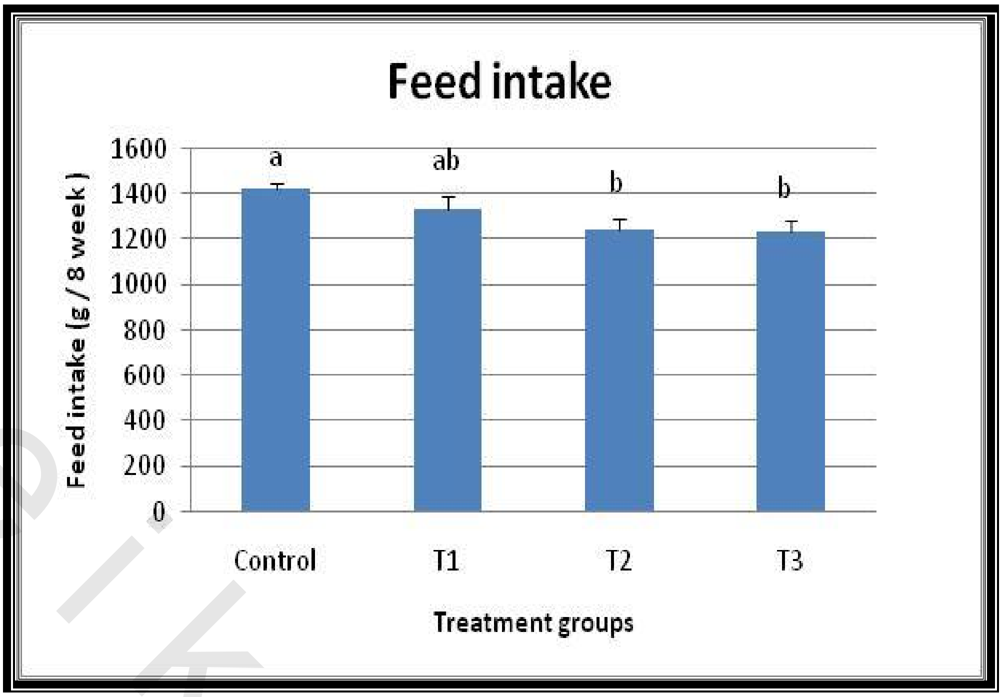

Figure (22): Effect of treatment with 5, 10 and 20 % rice starch manufacture by-product on feed intake

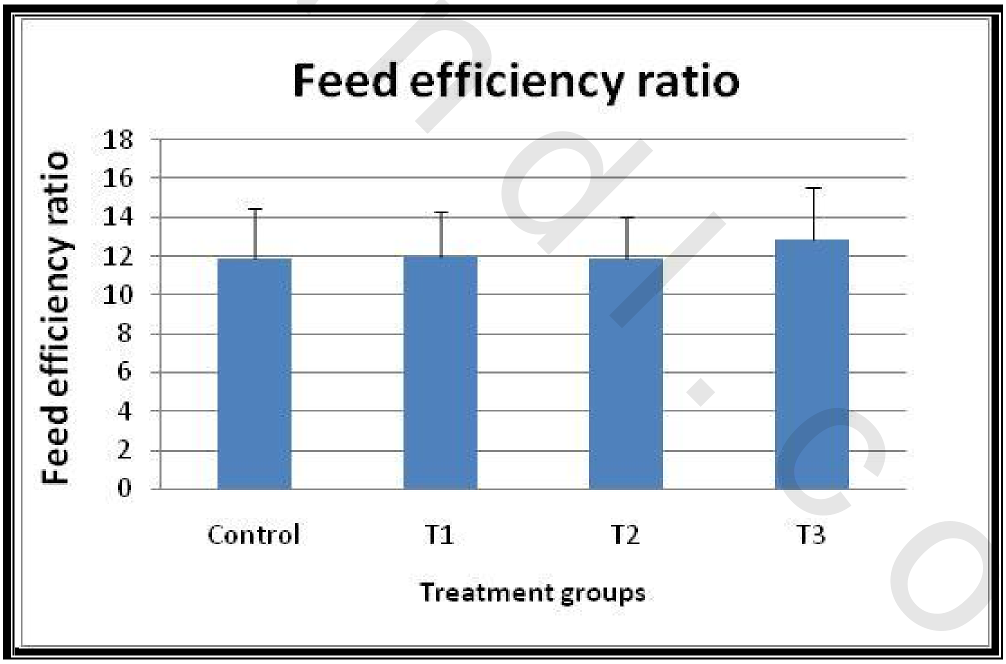

Figure (23): Effect of treatment with 5, 10 and 20 % rice starch manufacture by-product on feed efficiency ratio (FER)

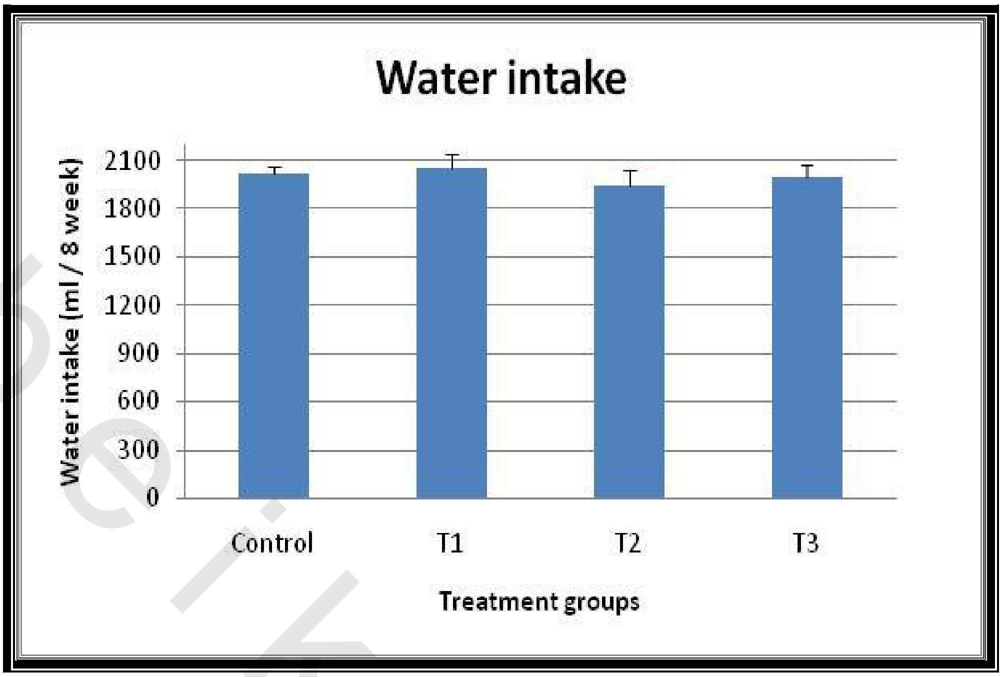

Figure (24): Effect of treatment with 5, 10 and 20 % rice starch manufacture by-product on water intake

4.5.3 Effect of treatment with 5%, 10% and 20% of rice starch manufacture by-product (RSMBP) on blood hematological parameters

4.5.3.1. Effect on hemoglobin (Hb)

Packed within each RBC is an estimated 200 to 300 million molecules of hemoglobin, which makes about 95% of the dry weight of each cell. Each hemoglobin molecule is composed of four protein chains. Each chain, called a globin, is bound to a red pigment, a heme molecule. Each heme molecule contains one iron atom. Therefore, one hemoglobin molecule contains four iron atoms. Each globin of hemoglobin is a protein and therefore consists of amino acids connected by peptide bonds in a specific sequence. Two identical chains consisting of 141 amino acids in their linear sequence are traditionally called alpha chains (α). The other two chains, also identical, consist of 146 amino acids are called beta chains (β) (Zakharov, 2009)[(183)]

Table 44 and Figure 25 showed the effect of experimental diet on hemoglobin concentration (Hb). The obtained results revealed that there was no significant effect of the treatment on Hb.

The values of blood hemoglobin in treatment groups are inagreement with the normal range values of rats (11.1-18.0 g/dl) (Dacie and Lewis, 1984) [(184)].

These results are inagreement with those reported by Ahmed *et al*. (2007)[(181)] who found non-significant differences in blood hemoglobin with rats fed on basal diet (control) and others fed on diet containing stabilized rice bran at 5% and 10% levels diets as rice Industrial By-products.

Table (44): Effect of treatment with 5, 10 and 20 % RSMBP on blood hemoglobin concentration (g/dl)

Treatment	Control	Treatments		
		5%	10%	20%
Hb (g / dl)	14.4939 ± 0.75669	15.1190 ± 0.54415	13.5746 ± 0.51805	15.1970 ± 0.64632

Values are expressed as Means ± S.E
n=5

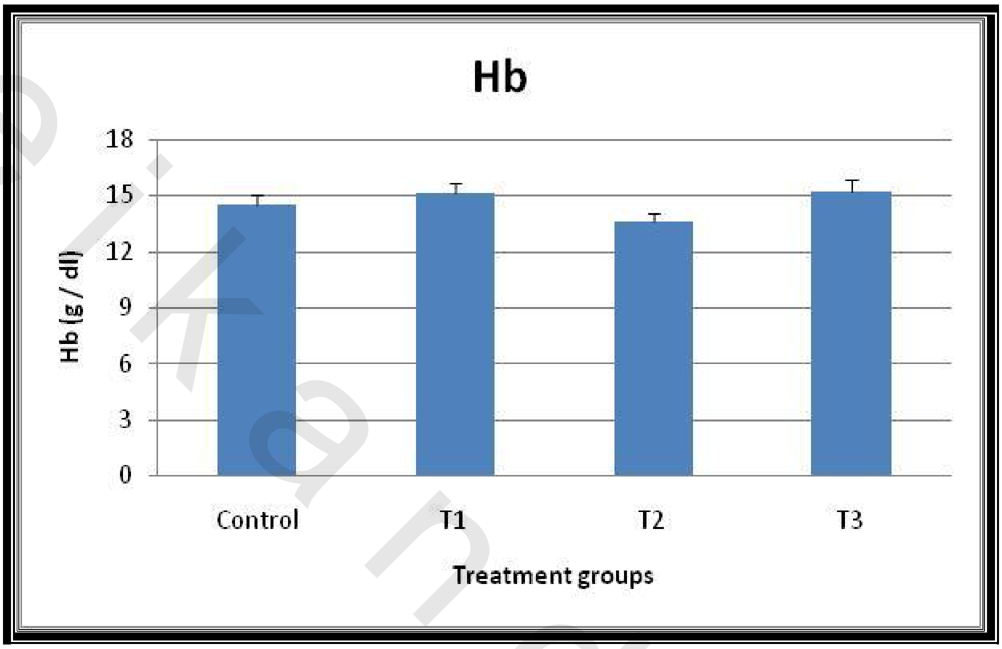

Figure (25): Effect of treatment with 5, 10 and 20 % RSMBP on hemoglobin concentration

4.5.3.2. Effect on white blood cells (WBCs)

White blood cell (WBC) or leukocytes is one of the three main types of blood cells. They are produced in the bone marrow and released into the blood. White blood cells are responsible for fighting infection. There are several types of white blood cells, including monocytes, lymphocytes, neutrophils, eosinophils, and basophils. They live for about three to four days in human body. Leukocytes are found throughout the body, including the blood and lymphatic system (Maton *et al*., 1997) [185].

Table 45 and Figure 26 showed the effect of experimental diet on white blood cells count (WBCs). A significant increase was observed in WBC (P<0.05) between control and treated group with 10 and 20 % RSMBP.

Ahmed *et al*. (2007)[181] found a significant decrease in white blood cells with rats fed on basal diet (control) and others fed on diet containing stabilized rice bran at 5% and 10% levels diets as rice Industrial By-products.

The values of white blood cells in treatment groups are inagreement with the normal range values of rats (3.0 – 15.0 x 10^3 cell/µl) (Dacia and Lewis, 1984) [184].

Table (45): Effect of treatment with 5, 10 and 20 % RSMBP on white blood cells (WBCs) count

Treatment	Control	Treatments		
		5%	10%	20%
WBC (count x10^3cell/μl)	4760 ± 318.748[b]	4920 ± 280.000[b]	6440 ± 318.748[a]	7120 ± 224.499[a]

Values are expressed as Means ± S.E
n = 5
[a,b] Means in a row with superscripts without a common letter differ, P <0.05

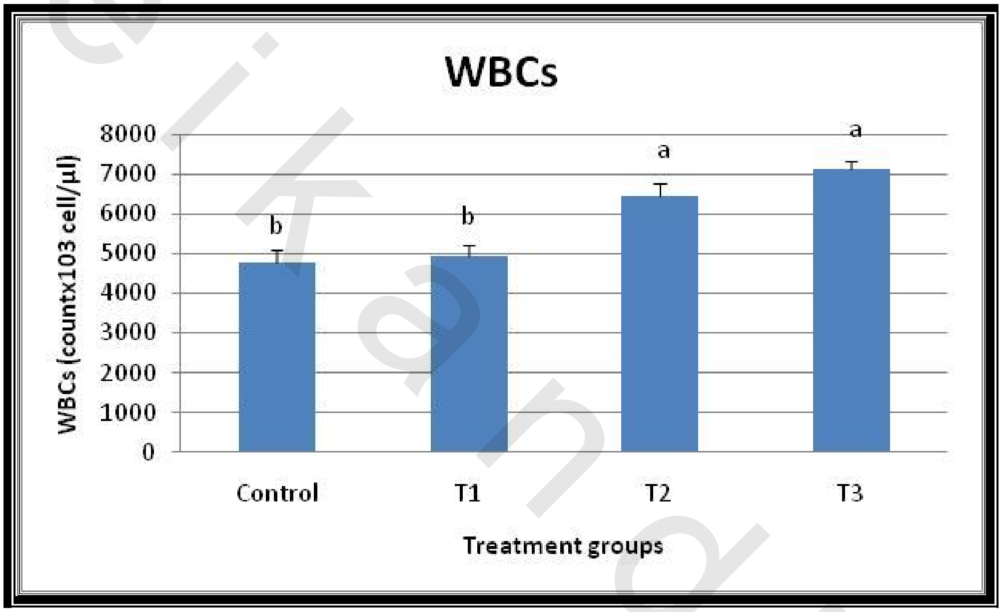

Figure (26): Effect of treatment with 5, 10 and 20 % RSMBP on white blood cells (WBCs) count

4.5.3.3. Effect on red blood cells (RBCs)

Human red blood cells (RBCs) are an important component of blood and play an essential role in human respiratory functions. They are responsible for the delivery of oxygen and removal of carbon dioxide from the organs (Deng *et al*., 2001) [186].

Table 46 and Figure 27showed the effect of experimental diet on red blood cells count (RBCs). No significant differences were observed in RBC count between control and treated groups.

The values of Red blood cells in treatment groups are inagreement with the normal range values of rats (8.15 – 9.75 x 10^6 cell/µl) (Jonson-Delaney, 2008) [187].

These results are inagreement with those reported by Ahmed *et al*. (2007)[181] who found non-significant differences in Red blood cells with rats fed on basal diet (control) and others fed on diet containing stabilized rice bran at 5% and 10% levels diets as rice Industrial By-products.

Table (46): Effect of treatment with 5, 10 and 20 % RSMBP on red blood cells count (count x 106 cell/µl)

Treatment	Control	Treatments		
		5%	10%	20%
(RBCs) (count x 10^6 cell/µl)	9.3800 ± 0.42030	9.5400 ± 0.57258	9.5600 ± 0.38484	9.6000 ±0.50843

Values are expressed as Means ± S.E
n = 5

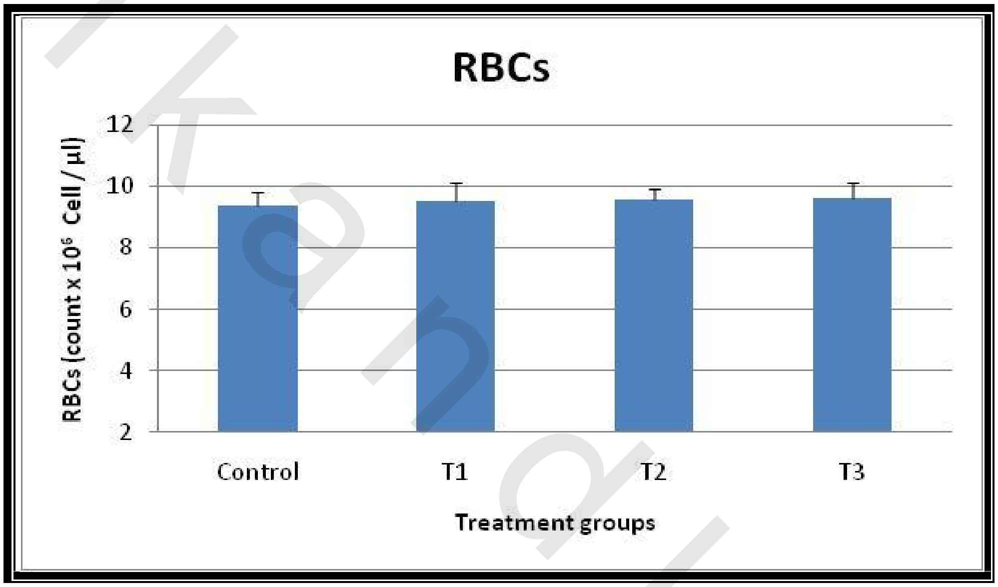

Figure (27): Effect of treatment with 5, 10 and 20 % RSMBP on Red blood cell co**unt**

4.5.3.4. Effect on hematocrit value (HCT)

Blood hematocrit (HCT) defined as the ratio of packed red blood cells volume to whole blood volume. Measurement of blood hematocrit is essential since it provides information on the total oxygen-carrying ability of patient. The normal ranges of the hematocrit are: 39–50% for male, 35–45% for female, and 30–40% for small children and babies, respectively (Jędrzejewska-Szczerska and Gnyba, 2011) [188].

The main reason of increased level of the hematocrit may be dehydration, burns, diarrhea, postpartum eclampsia, polycythemia vera. The high HCT level is also indicated as risk factors for heart and cerebral infraction because of hemoconcentration. Furthermore, the increased hematocrit is a factor of thrombus formation and increases a risk for thrombosis. This high HCT level is especially dangerous for patients with artificial heart, in dialysis, and during open-heart surgery. On the other hand, when the level of hematocrit is reduced, symptoms of anemia and bleeding are usually suspected, as well as diseases of the bone marrow, leukemia, malnutrition, and over hydration. Each change of hematocrit value affects the safe control of blood pump. Therefore, the hematocrit value as well as blood pressure should be controlled during the daily life as the indices of various physiological conditions in order to reduce the cardiovascular disease risk factor. It should be noted that the continuous monitoring of the HCT is also needed to perform appropriate dialysis and blood infusion (Jędrzejewska-Szczerska and Gnyba, 2011) [188].

Table 47 and Figure 28 showed the effect of experimental diet on the hematocrit percent. There were no significant changes between control and treated groups with 5, 10 and 20 % RSMBP.

The values of blood hematocrit in treatment groups are inagreement with the normal range values of rats (38.5-52%) (Dacia and Lewis, 1984; Research Animal Resources, 2007) [184,189].

These results are inagreement with those reported by Ahmed *et al*. (2007)[181] who found non-significant differences in blood hematocrit with rats fed on basal diet (control) and others fed on diet containing stabilized rice bran at 5% and 10% levels diets as rice Industrial By-products.

Table (47): Effect of treatment with 5, 10 and 20 % RSMBP on blood hematocrit percentage (g/dl)

Treatment	Control	Treatments		
		5%	10%	20%
HCT (%)	42.2878 ± 1.41268	43.8445 ± 1.41647	42.8386 ± 1.43377	46.6463 ± 1.61070

Values are expressed as Means ± S.E n = 5

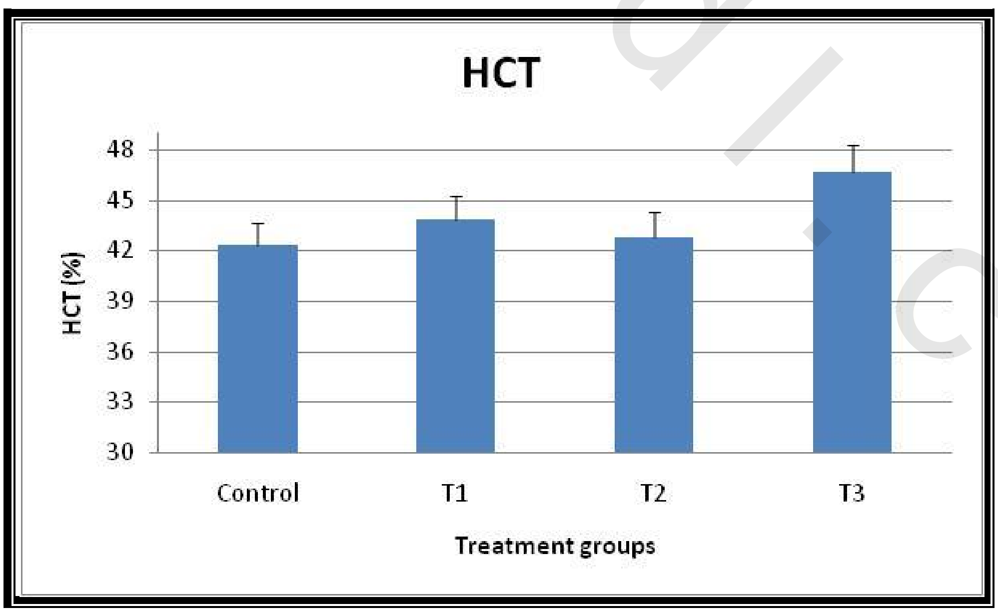

Figure (28): Effect of treatment with 5, 10 and 20 % RSMBP on blood HCT

4.5.3.5. Effect on mean corpuscular volume (MCV)

Table 48 and Figure 29 showed the effect of experimental diet on mean corpuscular volume (MCV). There was no significant effect between control and treated groups with 5, 10 and 20 % RSMBP.

The values of blood MCV in treatment groups are inagreement with the normal values of rats (44.96 – 56.2 %) (Dacia and Lewis (1984) [184]

These results are inagreement with those reported by Ahmed *et al*. (2007)[181] who found non-significant differences in blood MCV with rats fed on basal diet (control) and others fed on diet containing stabilized rice bran at 5% and 10% levels diets as rice industrial By-products.

Table (48): Effect of treatment with 5, 10 and 20 % RSMBP on blood MCV %

Treatments	Control	Treatments		
		5%	10%	20%
MCV (%)	45.5241± 2.81694	46.5129 ± 2.66207	45.2841 ± 3.11655	48.9131 ± 2.12211

Values are expressed as Means ± S.E
n = 5

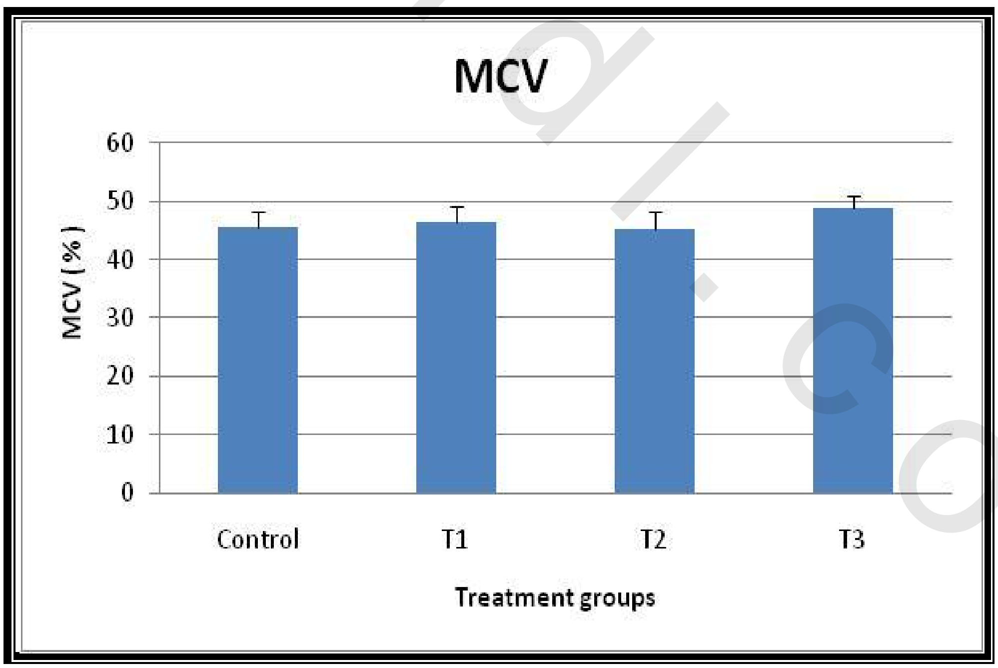

Figure (29): Effect of treatment with 5, 10 and 20 % RSMBP on blood MCV

4.5.3.6. Effect on mean corpuscular hemoglobin (MCH)

Table 49 and Figure 30 showed the effect of experimental diet on mean corpuscular hemoglobin (MCH). There were no significant differences between control and treated groups with 5, 10 and 20 % RSMBP.

The values of blood MCH in treatment groups are agreement with the normal values (14.3-18.3) (Johnson-Delaney, 1996) [187]

These results are in agreement with those reported by Ahmed *et al*. (2007)[181] who found non-significant differences in blood MCH with rats fed on basal diet (control) and others fed on diet containing stabilized rice bran at 5% and 10% levels diets as rice Industrial By-products.

Table (49): Effect of treatment with 5, 10 and 20 % RSMBP on blood MCH content (Pg)

Treatment	Control	Treatments		
		5%	10%	20%
MCH (Pg)	15.4440 ± 0.30716	16.0991 ± 1.20856	14.3144 ± 0.89147	16.0690 ± 1.33026

Values are expressed as Means ± S.E
(n = 5)

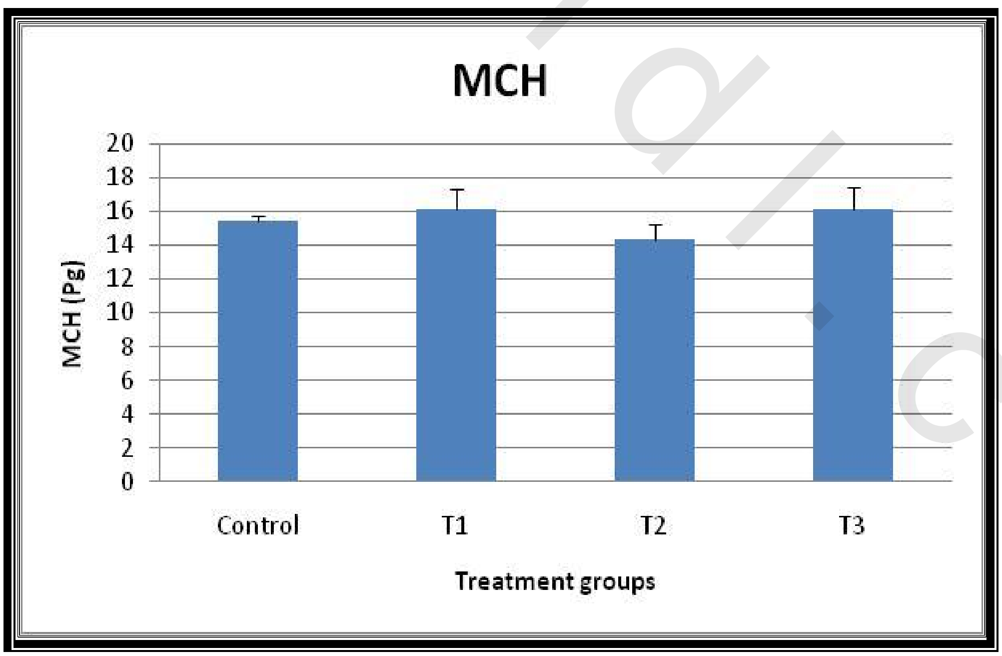

Figure (30): Effect of treatment with 5, 10 and 20 % RSMBP on blood MCH content (Pg)

4.5.3.7. Effect on mean corpuscular hemoglobin concentration (MCHC)

Table 50 and Figure 31 showed the effect of experimental diet on mean corpuscular hemoglobin concentration (MCHC). There was no significant effect between control and treated groups with 5, 10 and 20 % RSMBP.

The values of blood MCHC in treatment groups are inagreement with the normal values (21.6-42 g/dl) (Dacia and Lewis, 1984) [184].

These results are inagreement with those reported by Ahmed *et al***.** (2007)[181] who found non-significant differences in blood MCHC with rats fed on basal diet (control) and others fed on diet containing stabilized rice bran at 5% and 10% levels diets as rice Industrial By-products.

Table (50): Effect of treatment with 5, 10 and 20 % RSMBP on blood MCHC content

Treatment	Control	Treatments		
		5%	10%	20%
MCHC (g / dl)	34.5641±2.65142	34.6183 ± 1.60379	31.7136 ± 0.85670	32.9374 ± 2.67546

Values are expressed as Means ± S.E
n = 5

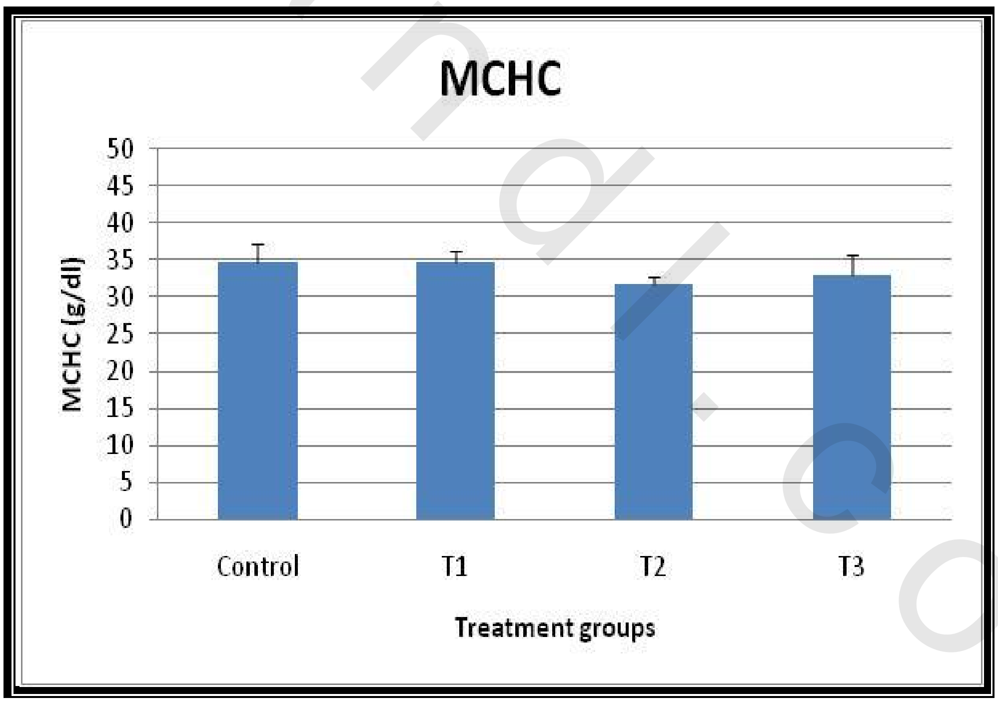

Figure (31): Effect of treatment with 5, 10 and 20 % RSMBP on blood MCHC

4.5.4. Effect of treatment with 5, 10 and 20% of rice starch manufacture by-product (RSMBP) on kidney functions

4.5.4.1. Effect on serum urea

Urea is synthesized in the body of many organisms as part of the urea cycle. Urea is, in essence, a waste product. However, it also plays a very important role in that it helps set up the countercurrent system in the nephrons. The countercurrent system in the nephrons allows for reabsorption of water and critical ions. Urea is reabsorbed in the inner medullary collecting ducts of the nephrons, thus raising the osmolarity in the medullary interstitium surrounding the thin ascending limb of the Loop of Henle. The greater the osmolarity of the medullary interstitium surrounding the thin ascending Loop of Henle, the more water will be reabsorbed out of the renal tubule back into the interstitium (and thus back into the body). Some of the urea from the medullary interstitium that helped set up the countercurrent system will also flow back into the tubule, through urea transporter, into the thin ascending limb of the loop of Henle, through the collecting ducts, and eventually out of the body as a component of urine, it is dissolved in blood (in a concentration of 2.5 – 7.5 mmol/l) and excreted by the kidney as a component of urine. In addition, a small amount of urea is excreted (along with sodium chloride and water) in sweat (Garba *et al*., 2007) [190]

Results in Table 51 and Figure 32 showed blood serum content of urea as mg/dl in control and treatment groups. From the results it was clear that there was no significant effect between treatment groups and control group.

These results are inagreement with those reported by Sharif (2009)[177] who found non-significant differences in serum urea with rats fed on basal diet (control) and others rats fed on diets containing rice bran oil as rice milling Industrial By-products.

Also these results are inagreement with Shallan *et al*. (2010)[191] who found no significant differences between rats fed on diet contains cooked brown rice high amylose (CBRH), rats fed on cooked brown rice low amylose (CBR L), rats fed on cooked white rice high amylose (CWRH), rats fed on cooked white rice low amylose (CWRL), rats fed on cooked prgerminated brown rice low amylose after 3 h of germination (CPGBRL), rats fed on cooked pre-germinated brown rice low amylose after 24 h of germination (CPGBRL) and rats fed on rice bread from brown rice low amylose (R B).

Chemical pathology values for male rats of different age groups for urea, ranged from 15 to 21.1 mg/dl (Jonson-Delaney, 1996) [184].

Shakib *et al*. (2014)[192] found non-significant differences in serum urea between patients fed on basal diet (control) and other fed on diets containing rice bran oil.

Table (51): Effect of treatment with 5, 10 and 20 % RSMBP on serum urea

Treatment	Control	Treatments		
		5%	10%	20%
Urea (mg/dl)	18.9028 ± 0.54268	22.3611 ± 1.23219	20.0917 ± 2.63099	19.0500 ± 0.99977

Values are expressed as Means ± S.E n = 5

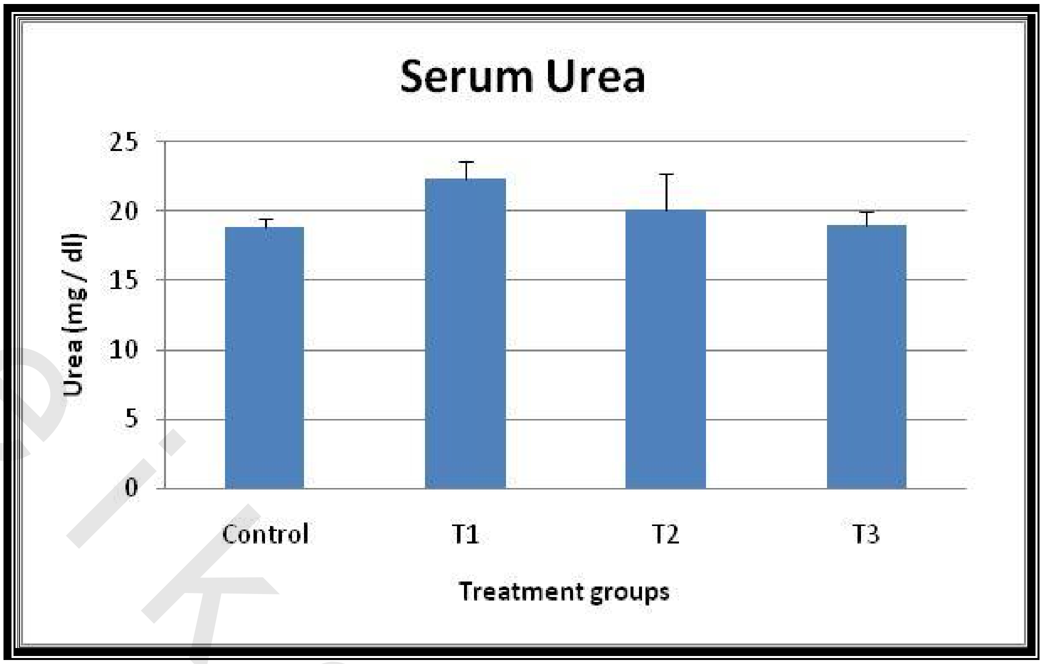

Figure (32): Effect of treatment with 5, 10 and 20 % RSMBP on serum urea

4.5.4.2. Effect on serum creatinine

Creatinine is a metabolic by product of muscle metabolism (it is derived from creatine and phosphocreatine). For the majority of patients the muscle turnover varies little from day to day, and the serum creatinine is more or less constant. Creatinine is filtered and excreted by the kidney. Serum creatinine is probably the most widely used indirect measure of glomerular filtration rate; it is easy and inexpensive to measure. There is little or no tubular re-absorption of creatinine. If the filtering of the kidney is deficient, creatinine blood levels rise. Therefore, creatinine levels in blood and urine may be used to calculate the creatinine clearance ($CrCl_3$), which reflects the glomerular filtration rate (GFR). The GFR is clinically important because it is a measurement of renal function. However, in cases of severe renal dysfunction, the creatinine clearance rate will be "overestimated" because active secretion of creatinine from the proximal tubule will account for a larger fraction of the total creatinine cleared (Delanghe *et al*., 1989) [(193)].

Results in Table 52 and Figure 33 showed blood serum creatinine for control and treated groups. It was found that there was no significant effect between control and treated groups.

These results are inagreement with those reported by Sharif (2009)[(177)] who found non-significant differences in serum creatinine with rats fed on basal diet (control) and others fed on diets containing rice bran oil as rice milling Industrial By-products.

The results are inagreement with Shallan *et al*. (2010)[(191)] who found no significant differences in serum creatinine between rats fed on diet contains cooked brown rice high amylose (CBRH), rats fed on cooked brown rice low amylose (CBR L), rats fed on cooked white rice high amylose (CWRH), rats fed on cooked white rice low amylose (CWRL), rats fed on cooked prgerminated brown rice low amylose after 3 h of germination (CPGBRL), rats fed on cooked pre-germinated brown rice low amylose after 24 h of germination (CPGBRL) and rats fed on rice bread from brown rice low amylose (R B).

On the other hand Shih *et al*. (2007) [194] reported that the high resistant starch in japonica rice diet reduced serum creatinine level.

Table (52): Effect of treatment with 5, 10 and 20 % RSMBP on serum creatinine

Treatment	Control	Treatments		
		5%	10%	20%
Creatinine (mg/dl)	1.1200 ± 0.05729	1.1229 ± 0.05792	0.9371 ± 0.09350	1.1500 ± 0.04534

Values are expressed as Means ± S.E n = 5

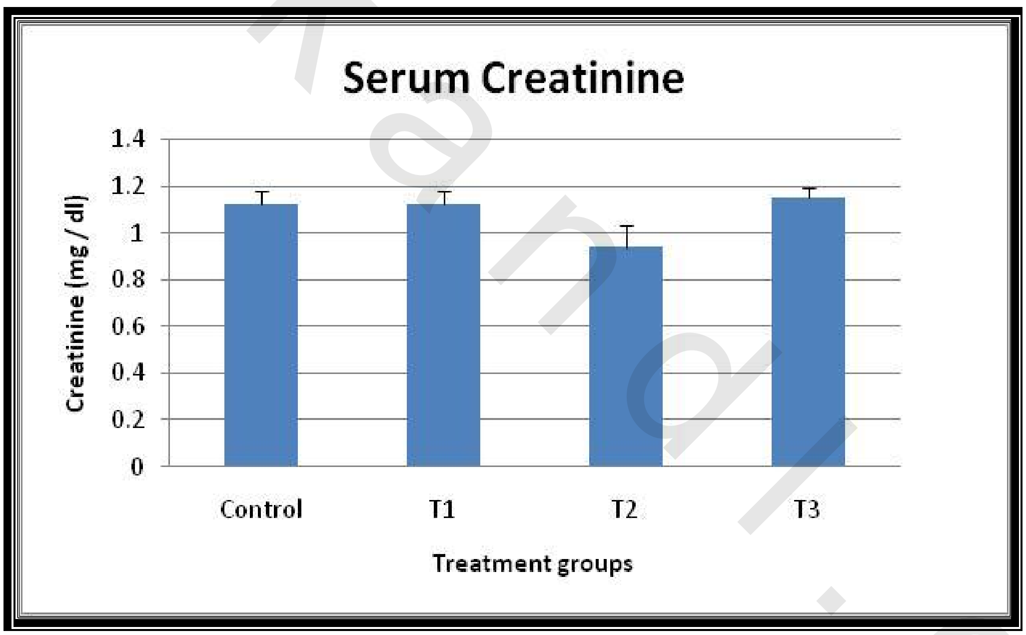

Figure (33): Effect of treatment with 5, 10 and 20 % RSMBP on serum creatinine

4.5.4.3. Effect on serum uric acid

Uric acid is a heterocyclic compound of carbon, nitrogen, oxygen, and hydrogen with the formula $C_5H_4N_4O_3$. It forms ions and salts known as urates and acid urates such as ammonium acid urate. Uric acid is a product of the metabolic breakdown of purine nucleotides. High blood concentrations of uric acid can lead to a type of arthritis known as gout. The chemical is associated with other medical conditions including diabetes and the formation of ammonium acid urate kidney stones (Ghalehkandi *et al*., 2012) [195].

Results in Table 53 and Figure 34 showed blood serum uric acid as mg/dl in control and treated groups. Results revealed that there was no significant effect between control and treatment group with 5% RSMBP, but there was a significant ($p < 0.05$) decrease between control and treated groups with 10 and 20%.

These results are agreement with Shih *et al*. (2007)[(194)] who found significant decrease in serum uric acid level between rats fed on control diet and others fed on Japonica rice diet.

Shakib *et al*. (2014)[(192)] who found a significant reduction in serum uric acid levels in patients fed on diet contains rice bran oil (RBO) as rice milling industry by-product compared with those fed on control diet.

These values of uric acid did not exceed the normal values (1.20-7.5) mg/dl (Jonson-Delaney, 1996) [(187)]

Table (53): Effect of treatment with 5, 10 and 20 % RSMBP on serum uric acid

Treatments	Control	Treatments		
		5%	10%	20%
Uric acid (mg/dl)	5.8000 ± 0.3590[a]	5.7143 ± 0.63577[a]	4.8214 ± 0.23090[ab]	4.0714± 0.29255[b]

Values are expressed as Means ± S.E n = 5

[a,b] Means in a row with superscripts without a common letter differ, P <0.05

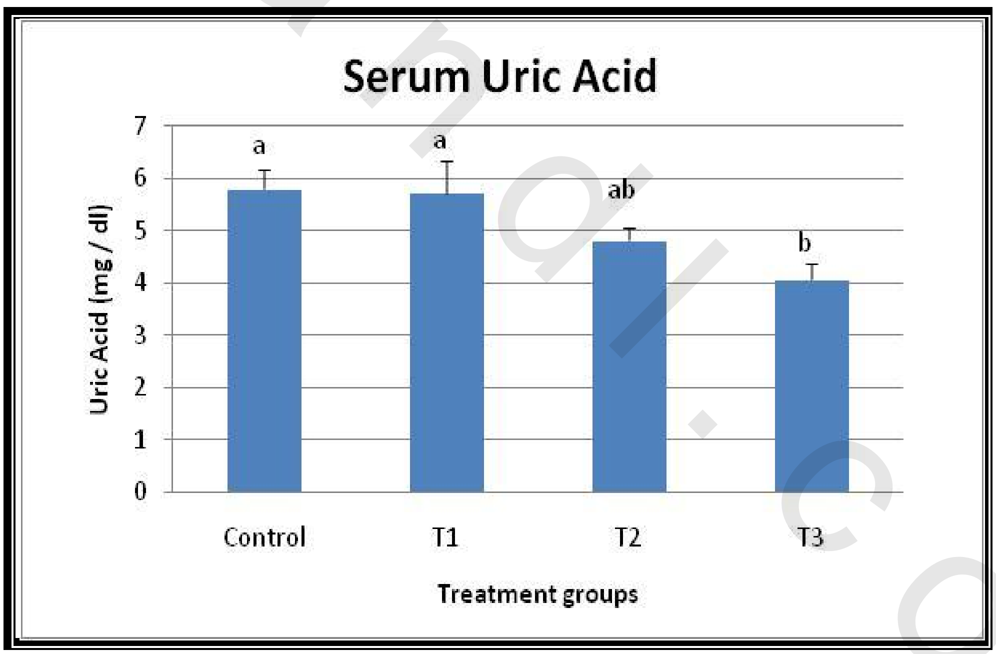

Figure (34): Effect of treatment with 5, 10 and 20 % RSMBP on serum uric acid

4.5.5. Effect of treatment with 5, 10 and 20% of rice starch manufacture by-product (RSMBP) on liver functions parameters

4.5.5.1. Effect on serum alanine aminotransferase (ALT)

ALT is an enzyme produced in hepatocytes, the major cell type in the liver. The level of ALT in the blood is increased in conditions in which liver cells are damaged or die. As cells are damaged, ALT leaks out into the blood stream. All types of hepatitis (viral, alcoholic, drug-induced, etc) cause hepatocyte damage that can lead to elevations in the serum ALT activity. The ALT level is also increased in cases of liver cell death resulting from other causes, such as shock or drug toxicity. The level of ALT may correlate roughly with the degree of cell death or inflammation; however, this is not always the case. An accurate estimate of inflammatory activity or the amount cell death can only be made by liver biopsy (Radosavljevic *et al*., 2008) [196]. The increased ALT levels in the serum of rats could be attributed to liver damage at cellular level (Drotman and Lohorn, 1978) [197] and also due to increased plasma membrane permeability (Ramazatto and carlin, 1978) [198].

Results in Table 54 and Figure 35 showed blood serum activity of alanine aminotransferase (ALT) in control and treated groups. The obtained results indicated that there was no significant effect between control and treatment group with 10% RSMBP, but there was a significant increase ($p < 0.05$) between control and treated groups with 5 and 20% RSMBP.

The results are inagreement with Al-Okbi *et al*. (2014)[199] who found a significant increase in ALT values between rats fed on normal diet and other fed on high fructose diet containing rice bran oil.

Shallan *et al.* (2010)[191] found a significant increase in ALT values between rats fed on control diet and others fed on cooked brown rice high amylose (CBRH), rats fed on cooked brown rice low amylose (CBRL) as well as rats fed on cooked white rice high and low amylose (CWRH), rats fed on cooked white rice low amylase (CWRL), rats fed on cooked pre-germinated brown rice low amylose after 3 h of germination (CPGBRL), rats fed on cooked pre-germinated brown rice low amylose after 24 h of germination (CPGBRL) and rats fed on rice bread from brown rice low amylose (RB).

Shakib *et al*. (2014)[192] found no significant effect in serum ALT levels in patients fed on diet contains rice bran oil (RBO) as rice milling industry by-product compared with those fed on baseline diet.

On the other hand Yang *et al.* (2012)[180] found a significant decrease in ALT values between rats fed on control diet and others fed on diet contains rice proteins extract by classical method with alkaline followed by precipitation with acidic solution (RP-A).

Chemical pathology reference values for male rats of different age groups for ALT, ranged from 17.5 to 30.2 IU/L (Jonson-Delaney, 1996) [187]

Table (54): Effect of treatment with 5, 10 and 20 % RSMBP on the activity of serum alanine aminotransferase (ALT)

Treatment	Control	Treatment		
		5%	10%	20%
ALT (IU/L)	27.420 ± 1.59072[b]	30.860 ±1.68511[a]	26.560 ± 1.56735[b]	34.620 ±3.44099[a]

Values are expressed as Means ± S.E
n = 5
[a,b] Means in a row with superscripts without a common letter differ, $P < 0.05$.

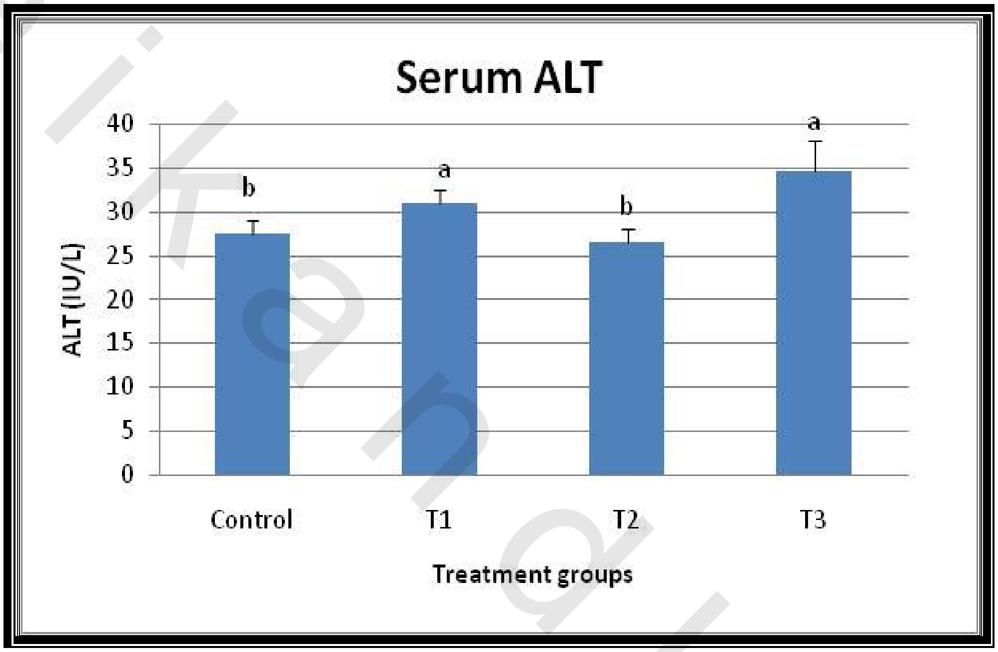

Figure (35): Effect of treatment with 5, 10 and 20 % RSMBP on the activity of serum alanine aminotransferase (ALT)

4.5.5.2. Effect on serum aspartate aminotransferase (AST)

AST is an enzyme normally present in liver and heart cells. AST is released into blood when the liver or heart is damaged. The blood AST levels are thus elevated with liver damage (for example, from vital hepatitis) or with an insult to the heart (for example, from a heart attack). Some medications can also raise AST levels. AST is also known as serum glutamic oxaloacetic transaminase (SGOT) (Aly El-Deen, 2009) [(200)].

Results in Table 55 and Figure 36 showed blood serum activity of aspartate aminotransferase (AST) in control and treated groups. It was found that there was no significant effect between control and treated groups with 5, 10 and 20% RSMBP.

These results are inagreement with those reported by Sharif (2009)[(177)] who found non-significant differences in serum AST between rats fed on basal diet (control) and other rats fed on diets containing rice bran oil as rice milling industrial By-products.

Shakib *et al*. (2014)[192] found non-significant differences in serum AST between patients fed on basal diet (control) and others fed on diets containing rice bran oil.

On the other hand, Yang *et al.* (2012)[180] found a significant decrease in AST values between rats fed on control diet and other fed on diet contains rice proteins extraction by classical method with alkaline followed by precipitation with acidic solution (RP-A).

Al-Okbi *et al*. (2014)[199] reported that a significant increase was found in AST values between rats fed on normal diet and others fed on high fructose diet containing rice bran oil.

Chemical pathology reference values for male rats of different age groups for AST, ranged from 45.7 to 80.8 IU/L (Jonson-Delaney, 1996) [187]

Table (55): Effect of treatment with 5, 10 and 20 % RSMBP on the activity of serum aspartate aminotransferase (AST)

Treatment	Control	Treatments		
		5%	10%	20%
AST (IU/L)	82.0000 ± 2.94534	82.2000 ±4.02057	81.3000 ± 3.67967	68.4000±6.28769

Values are expressed as Means ± S.E
n = 5

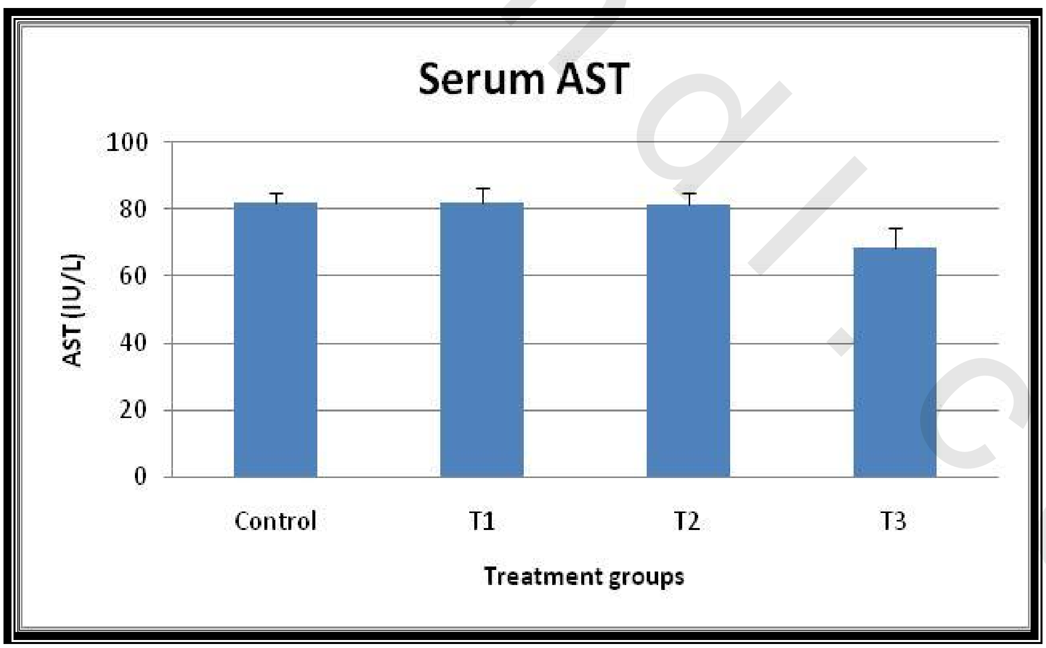

Figure (36): Effect of treatment with 5, 10 and 20 % RSMBP on the activity of serum aspartate aminotransferase (AST)

4.5.5.3. Effect on serum alkaline phosphatase (ALP)

ALP is an enzyme in the cells lining the biliary ducts of the liver. ALP levels in plasma will rise with bile duct obstruction, intrahepatic cholestasis or infiltrative diseases of the liver. ALP is also present in bone and placental tissues, so it is higher in growing children (as their bones are being remodelled) and elderly patients with paget's disease (Aly El-Deen, 2009) [200].

Results in Table 56 and Figure 37 showed blood serum activity of alkaline phosphatase (ALP) in control and treated groups. Results indicated that there was no significant effect between control and treated groups with 5, 10 and 20% RSMBP.

The values of ALP in treatment groups are inagreement with the normal values (56.8 - 128) IU/L (Jonson-Delaney, 1996) [187].

Table (56): Effect of treatment with 5, 10 and 20 % RSMBP on the activity of serum alkaline Phosphatase (ALP)

Treatment	Control	Treatments		
		5%	10%	20%
ALP (IU/L)	58.9091 ± 2.56950	58.1265±8.21443	68.5227±18.54722	66.1705 ±7.03038

Values are expressed as Means ± S.E
n = 5

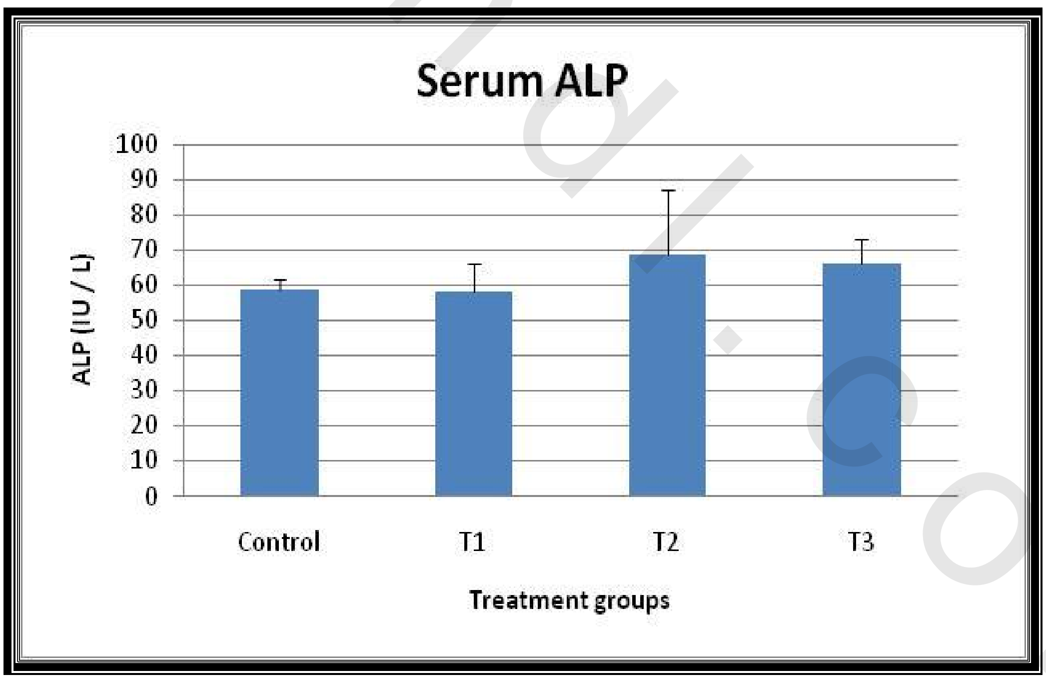

Figure (37): Effect of treatment with 5, 10 and 20 % RSMBP on the activity of serum alkaline phosphatase (ALP)

4.5.5.4. Effect on serum acid phosphatase (ACP)

Acid Phosphatases are classified as hydrolase enzymes that hydrolyze aliphatic and aromatic phosphate esters to liberate phosphates. According to the name itself functionally these enzymes are active at acid pH. These are widespread in nature and also found in many animals and plant species. In 1959, Burstone reported the potent activity of the enzyme in bone metabolism such as osteoclasts and osteoblasts respectively (Burstone, 1959) [(201)].

Acid Phosphatases (ACP) are present in many cells and tissues such as prostrate, liver, kidney, spleen, erythrocyte, platelet and osteoclast. It is consider as a tool of clinical investigation and intervention in human, for example it is done to assess enzymatic damage caused by kidney disease, heart attack, systemic infection, anemia, hepatitis, thrombophlebitis, hyperparathyroidism etc (Bull *et al*., 2002)[(202)].

Results in Table 57 and Figure 38 showed blood serum activity of acid phosphatase (ACP) in control and treated groups. It was found that there was a significant ($p < 0.05$) decrease between control and treated group with 20% RSMBP.

The values of ACP in treatment groups are agreement with the normal values (28.9 - 47.6) IU/L (Jonson-Delaney, 1996) [(187)]

Table (57): Effect of treatment with 5, 10 and 20 % RSMBP on the activity of serum acid phosphatase (ACP) content (IU/L)

Treatment	Control	Treatments		
		5%	10%	20%
ACP (IU/L)	41.4417± 0.91664[a]	41.4133 ± 0.33302[a]	39.1833 ± 1.58167[a]	34.1042 ±0.14224[b]

Values are expressed as Means ± S.E n = 5

[a,b] Means in a row with superscripts without a common letter differ, P <0.05

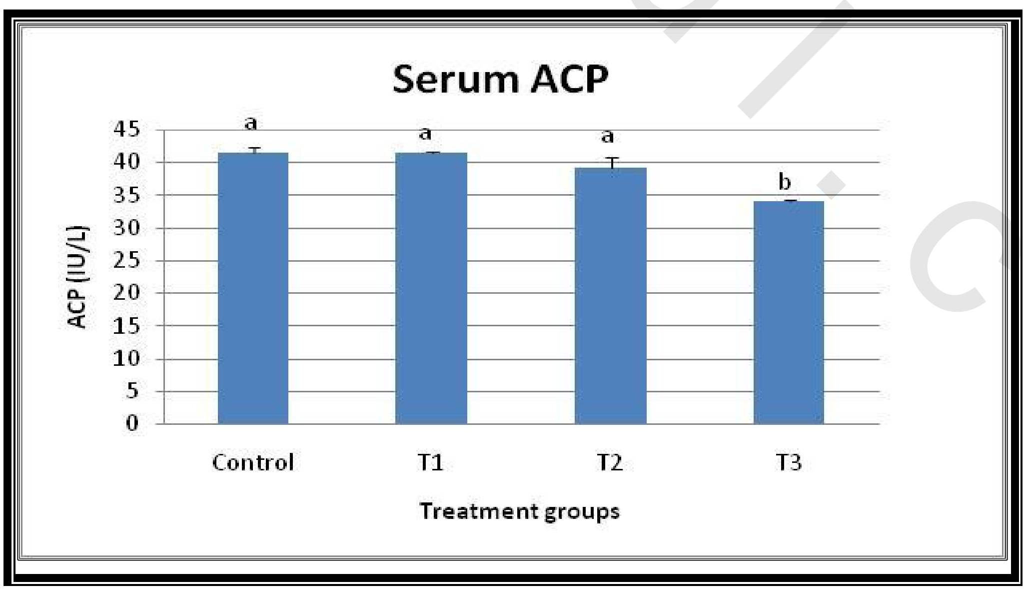

Figure (38): Effect of treatment with 5, 10 and 20 % RSMBP on the activity of serum acid phosphatase (ACP)

4.5.5.5. Effect on serum bilirubin

Bilirubin (formerly referred to as hematoidin) is the yellow breakdown product of normal heme catabolism. Heme is formed from hemoglobin, a principle component of red blood cells. Bilirubin is excreted in bile, and its levels are elevated in certain diseases, it is responsible for the yellow color of bruises and the yellow discoloration in jaundice. Bilirubin reduction in the gut leads to a product called urobilinogen which is then oxidized to urobilin which is excreted in the urine (Aly El-Deen, 2009) [200].

Results in Table 58 and Figure 39 showed blood serum content of bilirubin in control and treated groups. From the results, it was found that there was no significant effect between control and treated groups with 5, 10 and 20% RSMBP.

The values of bilirubin in treatment groups are agreement with the normal values (28.9 -47.6) IU/L (Jonson-Delaney, 1996) [187]

Al-Okbi *et al*. (2014)[199] reported that a significant increase was found in bilirubin values between rats fed on normal diet and other fed on high fructose diet containing rice bran oil.

Table (58): Effect of treatment with 5, 10 and 20 % RSMBP on serum bilirubin content

Treatment	Control	Treatments		
		5%	10%	20%
Bilirubin (IU/L)	0.8428 ± 0.07624	0.9079 ± 0.08087	0.9361 ± 0.07087	0.8675 ± 0.06825

Values are expressed as Means ± S.E
n = 5

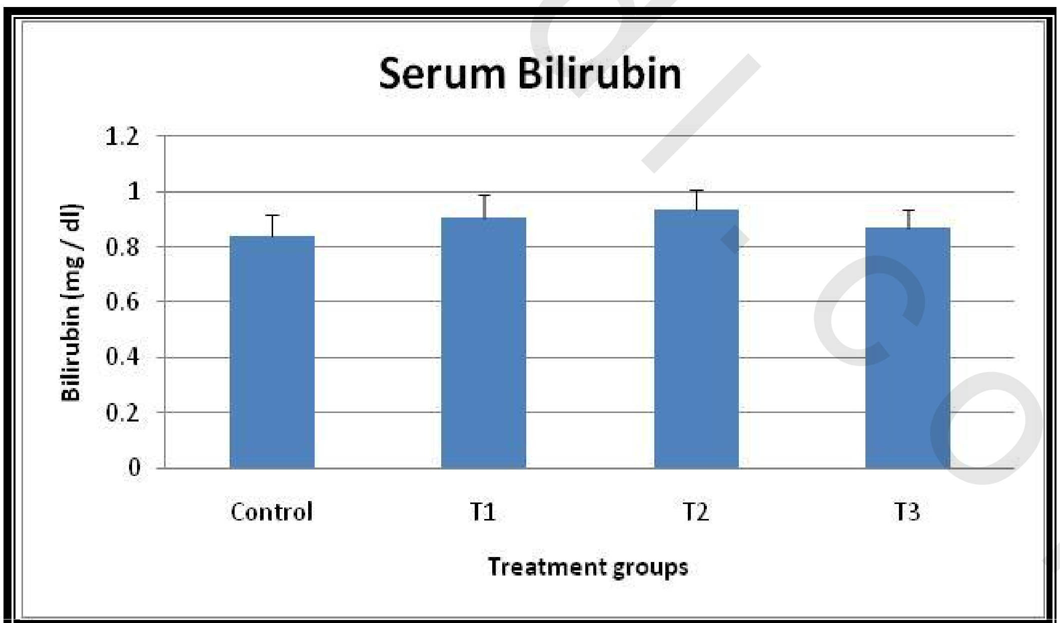

Figure (39): Effect of treatment with 5, 10 and 20 % RSMBP on serum bilirubin

4.5.5.6. Effect on serum total protein (TP)

TP is a biochemical test for measuring the total amount of protein in blood plasma or serum. Protein in the plasma is made up of albumin and globulin. The globulin in turn is made up of α1, α2, β and γ globulins. These fractions can be quantitated using protein electrophoresis, but the TP test is a faster and cheaper test that estimates the total of all fractions together. The reference range for TP is 60 – 85 g/l. Concentrations below the reference range usually reflect low albumin concentration, for instance in liver disease or acute infection. Concentrations above the reference range are found in paraproteinaemia, Hodgkin's lymphoma or leukemia (Bradbury *et al*., 1987) [(203)].

Results in Table 59 and Figure 40 showed blood serum content of total protein (TP) in control and treated groups. The results revealed that there was no significant differences between control and treated groups with 5, 10, 20% RSMBP.

These results are inagreement with those reported by Ahmed *et al*. (2007)[(181)] who found non-significant differences in serum total protein in rats fed on control diet and other fed on diet contains rice bran either at the 5% or 10% level.

Yang *et al.* (2012)[(180)] found no significant in total protein values between rats fed on control diet and other fed on diet contains rice proteins extraction by classical method with alkaline followed by precipitation with acidic solution (RP-A).

Sharif (2009)[(177)] found no significant differences in serum total protein with rats fed on basal diet (control) and others rats fed on diets containing rice bran as rice Industrial By-products which ranged between 6.15 to 6.33 g/dl.

The values of total protein are inagreement with the normal values (5.6 – 7.6) g/dl according to (Johnson-Delaney, 1996) [(187)]

Table (59): Effect of treatment with 5, 10 and 20 % RSMBP on serum total protein (TP)

Treatment	Control	Treatments		
		5%	10%	20%
TP (g/dl)	6.3909 ± 0.44833	5.6318 ± 0.23118	5.6341 ± 0.06462	5.6000 ± 0.28301

Values are expressed as Means ± S.E
n = 5

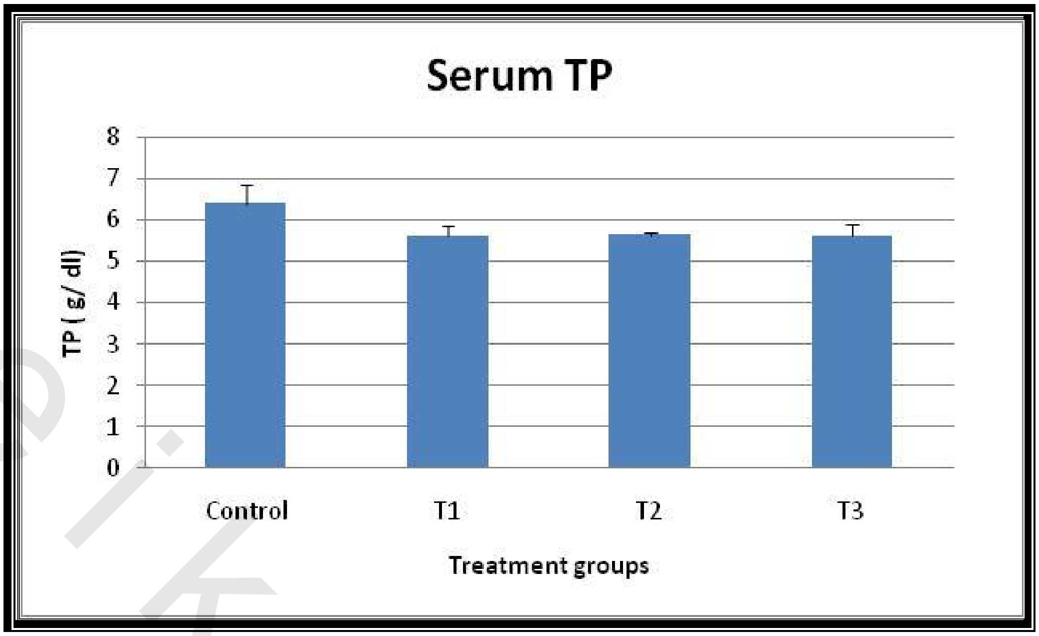

Figure (40): Effect of treatment with 5, 10 and 20 % RSMBP on serum total protein (TP)

4.5.5.7. Effect on serum albumin

Albumin refers generally to any protein with water solubility, which is moderately soluble in concentrated salt solutions, and experiences heat coagulation (protein denaturation). Serum albumin is the most abundant blood plasma protein and is produced in the liver and forms a large proportion of all plasma protein. It normally constitutes about 60% of human plasma protein, all other protein in blood plasma are referred to collectively as globulins, serum albumins are important in regulating blood volume by maintaining the osmotic pressure of the blood compartment. They also serve as carries for molecules of low water solubility, including lipid soluble hormones, bile salt, bilirubin, free fatty acids (apoprotein), calcium, iron (transferring), and some drugs (Aly El-Deen, 2009)[(200)].

Results in Table 60 and Figure 41 showed blood serum content of albumin in control and treated groups. There was no significant differences between control and treated groups with 5, 10, 20% RSMBP.

These results are in agreement with those reported by Sharif (2009)[(177)] who found non-significant differences in serum albumin with rats fed on basal diet (control) and others rats fed on diets containing rice bran as rice Industrial By-products which ranged from 2.93 to 3.09 g / dl.

Yang *et al.* (2012)[(180)] found no significant changes in albumin values between rats fed on control diet and other fed on diet contains rice proteins extraction by classical method with alkaline followed by precipitation with acidic solution (RP-A).

The obtained results are compatible with reference range (2.8 – 4.4) g/dl (Araújo *et al*., 2005)[(204)].

Table (60): Effect of treatment with 5, 10 and 20 % RSMBP on serum albumin

Treatment	Control	Treatments		
		5%	10%	20%
Albumin (g/dl)	3.7100 ± 0.23456	3.6888 ± 0.16902	3.6012 ± 0.12323	3.7925 ± 0.15509

Values are expressed as Means ± S.E
n = 5

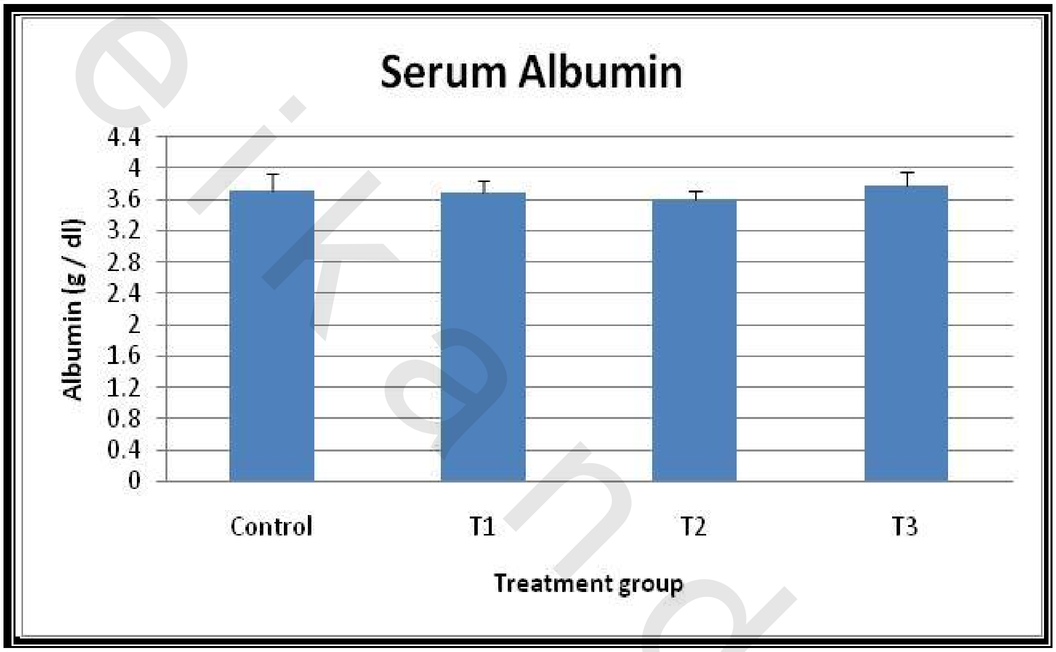

Figure (41): Effect of treatment with 5, 10 and 20 % RSMBP on serum albumin

4.5.5.8. Effect on serum globulin

Results in Table 61 and Figure 42 showed blood serum content of globulin in control and treated groups. It was indicated there was no significant differences between control and treated groups with 5, 10, 20% RSMBP.

The results are in agreement with Yang *et al.* (2012)[180] who found no significant in serum globulin values between rats fed on control diet and others fed on diet contains rice proteins extraction by classical method with alkaline followed by precipitation with acidic solution (RP-A).

Sharif (2009)[177] found non-significant differences in serum globulin with rats fed on basal diet (control) and other rats fed on diets containing rice bran as rice milling industrial By-products.

The present results are compatible with reference range (1.8 – 3) g/dl (Johnson-Delaney, 1996) [187].

Table (61): Effect of treatment with 5, 10 and 20 % RSMBP on serum globulin

Treatment	Control	Treatments		
		5%	10%	20%
Globulin (g/dl)	2.6809 ± 0.34935	1.9431 ± 0.26544	2.0328 ± 0.11046	1.9675 ± 0.22766

Values are expressed as Means ± S.E n = 5

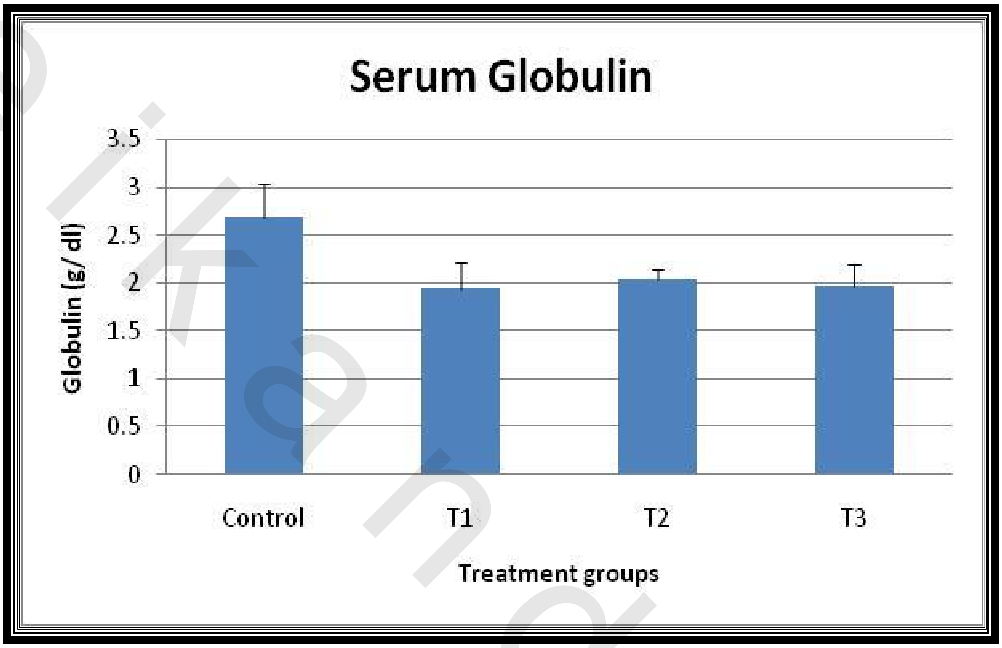

Figure (42): Effect of treatment with 5, 10 and 20 % RSMBP on serum globulin

4.5.6. Effect of treatment with 5, 10 and 20% of rice starch manufacture by-product (RSMBP) on lipid profiles

4.5.6.1. Effect on serum total lipids (TL)

Biological lipids are a chemically diverse group of compounds, the common and defining feature of which is their insolubility in water. The biological functions of the lipids are as diverse as their chemistry. Fats and oils are the principal stored forms of energy in many organisms. Phospholipids and sterols are major structural elements of biological membranes. Other lipids, although present in relatively small quantities, play crucial roles as enzyme cofactors, electron carriers, light absorbing pigments, hydrophobic anchors for proteins, “chaperones” to help membrane proteins fold, emulsifying agents in the digestive tract, hormones, and intracellular messengers (Nelson and Cox, 2000) [(205)].

Blood lipid consists of cholesterol, triglyceride, phospholipid, and free fatty acid (FFA) (Joo *et al.*, 2010) [(206)].

Results in Table 62 and Figure 43 showed blood serum content of total lipids (TL) in control and treated groups. The obtained results indicated that there was no significant effect between control and treated groups with 5, 10, 20% RSMBP.

Chemical pathology values for male rats of different age groups for total lipids, ranged from 0.7 to 4.15 g/dl (Jonson-Delaney, 1996) [187].

Yang *et al.* (2012)[180] found significant decrease in total lipids values between rats fed on control diet and others fed on diet contains rice proteins extraction by classical method with alkaline followed by precipitation with acidic solution (RP-A).

Table (62): Effect of treatment with 5, 10 and 20 % RSMBP on serum total lipids (TL)

Treatment	Control	Treatments		
		5%	10%	20%
TL (g/dl)	4.3412 ± 0.12652	4.1586 ± 0.11533	4.1480 ± 0.06621	4.0540 ± 0.14239

Values are expressed as Means ± S.E

n = 5

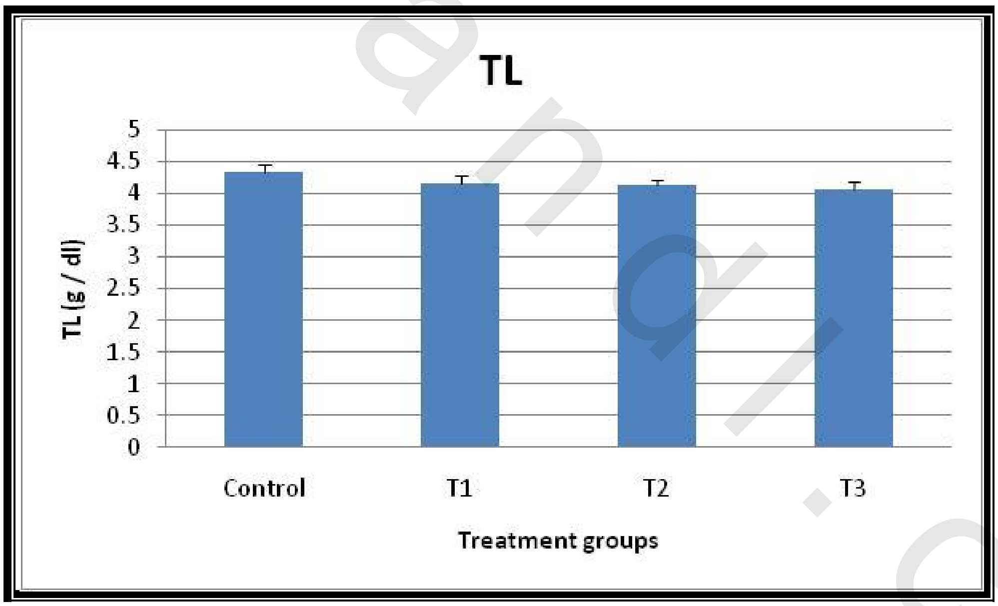

Figure (43): Effect of treatment with 5, 10 and 20 % RSMBP on serum total lipids (TL)

4.5.6.2. Effect on serum triglycerides (TG)

Triglycerides are esters (derived from glycerol and three fatty acids) that play an important role in metabolism. Triglycerides, as major components of very low density lipoprotein (VLDL) and chylomicrons, play an important role in metabolism as energy sources and transporters of dietary fat. They contain more than twice as much energy (9 kcal/g) as caebohydrates and proteins. Triglycerides cannot pass through cell membranes freely. Special enzymes on the walls of blood vessels called lipoprotein lipases must break down TG into fatty acids and glycerol. Fatty acids can then be taken up by cells via the fatty acid transporter (FAT) (Nelson and Cox, 2000; Ononogbu, 1988) [205,207].

Results in Table 63 and Figure 44 showed blood serum content of triglycerides (TG) in control and treated groups. Results revealed a significant ($p < 0.05$) decrease between control and treated group with 20% RSMBP.

Chemical pathology reference values for male rats of different age groups for triglycerides, ranged from 26 to 145 mg/dl (Jonson-Delaney, 1996) [187]

The results are in agreement with Yang *et al.* (2012)[180] who found a significant decrease in triglycerides values between rats fed on control diet and others fed on diet contains rice proteins extraction by classical method with alkaline followed by precipitation with acidic solution (RP-A).

Shakib *et al*. (2014)[192] found a significant decrease in serum triglycerides levels in patients fed on diet contains rice bran oil (RBO) as rice milling industry by-product compared with those fed on baseline diet

These results are inagreement with Peter (1992) [208] who reported that high amylose rice have lowering effect of blood triglycerides.

Miriam *et al.* (1995) [209] reported that the dietary high amylose when compared with low amylose lowered the blood triglyceride concentration.

Lzumi *et al*. (2007) [210] found that feeding with 3% milled rice were significantly lower total triglycerides.

The present results are inagreement with those reported by Sharif (2009)[177] who found significant decrease in serum triglycerides with rats fed on basal diet (control) and otherfed on rice bran as rice Industrial By-products.

Revilla *et al.*(2009)[211] reported that γ-oryzanol and phenolic compounds which found in brown rice has a greater effect on lowering triglyceride.

Al-Subhi and Hejazi (2013) [212] reported that rats fed on brown and white rice high and low amylose significantly lowered serum triglycerides.

Table (63): Effect of treatment with 5, 10 and 20 % RSMBP on serum triglycerides (TG)

Treatment	Control	Treatments		
		5%	10%	20%
TG (g/dl)	140.387±4.90615 [a]	134.237 ± 8.42169[a]	139.982 ±7.68803[a]	114.202±4.34758[b]

Values are expressed as Means ± S.E n = 5

[a,b] Means in a row with superscripts without a common letter differ, $P < 0.05$

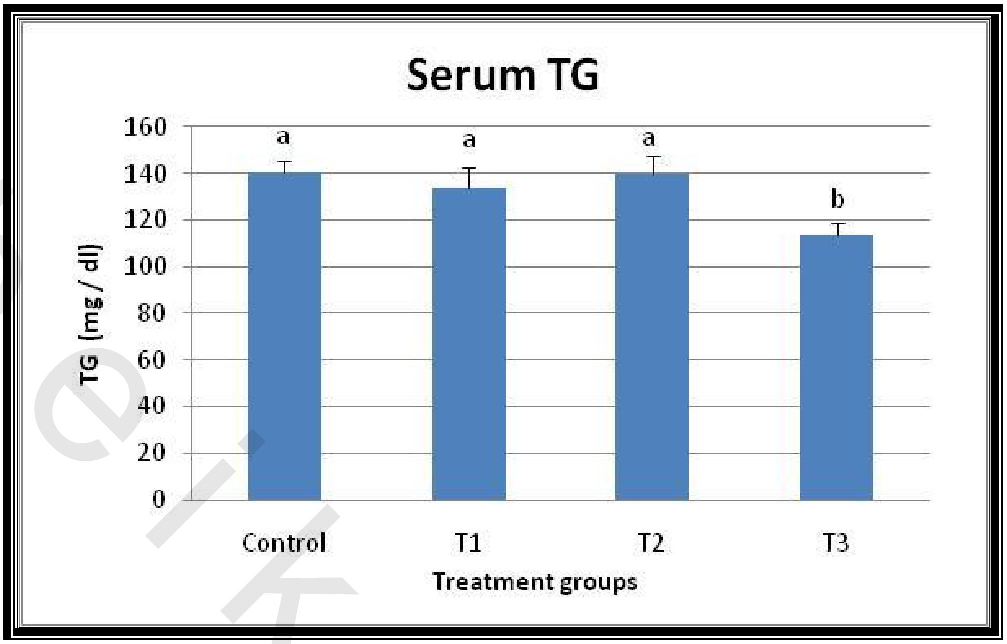

Figure (44): Effect of treatment with 5, 10 and 20 % RSMBP on serum triglycerides (TG)

4.5.6.3. Effect on serum cholesterol

Cholesterol is a lipid found in the cell membranes of all animal tissues, and it is transported in the blood plasma of all animals. Cholesterol is also a sterol (a combination steroid and alcohol). Because cholesterol is synthesized by all eukaryotes, trace amounts of cholesterol are also found in membranes of plants and fungi, it also plays major roles in membrane permeability and fluidity and also serves as a precursor of bile acids, steroid hormones and fat- soluble vitamins (Oslon, 1998; Brunzell, 2008)[213,214].

Cholesterol is transported in the bloodstream in association with lipoproteins which are named according to their density. Though cholesterol is physiologically important in the body, high levels of it in blood (hypercholesterolemia) have been found to be a major risk factor for the development of atherosclerosis (Brown and Goldstein, 1992) [215].

Results in Table 64 and Figure 45 showed blood serum content of cholesterol in control and treated groups. From the results it was found that there was a significant ($p< 0.05$) decrease between control and treated group with 20% RSMBP.

Chemical pathology reference values for male rats of different age groups for cholesterol ranged from 75.4 to 134.1mg/dl (TTL, 2008) [216].

Yang *et al.* (2012)[180] found a significant decrease in cholesterol values between rats fed on control diet and other fed on diet contains rice proteins extraction by classical method with alkaline followed by precipitation with acidic solution (RP-A).

Sharif (2009)[177] found a significant decrease in cholesterol in rats fed on diet contains rice bran as rice industrial by-product compared with rats fed on control diet..

Shih *et al.* (2007) [194] reported that the high resistant starch in rice was reduced serum cholesterol.

Izumi *et al.* (2007) [210] reported that feeding with 3% milled rice was significantly lower total cholesterol than polished rice.

Revilla *et al.* (2009)[211] reported that γ-oryzanol and phenolic compounds which found in brown rice has a greater effect on lowering total cholesterol.

Al-Subhi and Hejazi (2013) [212] reported that rats fed on brown and white rice high and low amylose significantly lowered total cholesterol.

Mesomya *et al*. (2009)[217] found no significant differences in cholesterol values between rats fed on control diet and other fed on diet contains cooked conventional rice, cooked unpolished organic rice and cooked unpolished conventional rice.

Shakib *et al*. (2014)[192] found a significant decrease in serum cholesterol levels in patients fed on diet contains rice bran oil (RBO) as rice milling industry by-product compared with those fed on baseline diet.

Table (64): Effect of treatment with 5, 10 and 20 % RSMBP on serum cholesterol

Treatment	Control	Treatments		
		5%	10%	20%
Cholesterol (mg/dl)	132.500 ± 7.18521[a]	120.893 ± 4.88436[ab]	126.692±1.98124[a]	106.143±6.34984[b]

Values are expressed as means ± S.E n = 5

[a,b] Means in a row with superscripts without a common letter differ, P <0.05

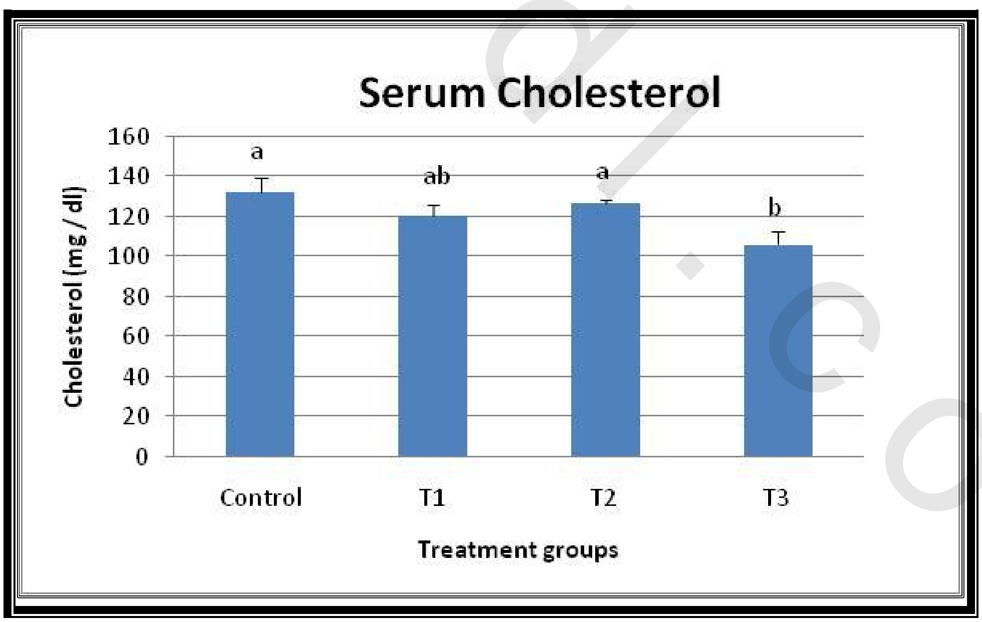

Figure (45): Effect of treatment with 5, 10 and 20 % RSMBP on serum cholesterol

4.5.6.4. Effect on serum low density lipoprotein - cholesterol (LDL)

LDL is a lipoprotein that transports cholesterol and triglycerides from the liver to peripheral tissues. LDL also regulates cholesterol synthesis at these sites. It commonly appears in the medical setting as part of cholesterol blood test, and since high levels of LDL-cholesterol can signal medical problems like cardiovascular disease, it is sometimes called "bad cholesterol" (Cromwell and Otvos, 2004)[218].

Results in Table 65 and Figure 46 showed blood serum content of low-density lipoprotein-cholesterol (LDL) in control and treated groups. The results indicated that there was a significant ($p < 0.05$) decrease between control and treated group with 5, 10 and 20% RSMBP.

Chemical pathology Reference values for the serum LDL of male albino rats of varied ages ranged from 2.39 to 106.51 mg/dl (Ihedioha et al., 2013) [219]

The results are inagreement with Yang *et al.* (2012)[180] who found a significant decrease in LDL values between rats fed on control diet and others fed on diet contains rice proteins extraction by classical method with alkaline followed by precipitation with acidic solution (RP-A).

Sharif (2009)[177] found a significant decrease in LDL in rats fed on diet contains rice bran as rice industrial by-product compared with rats fed on control diet.

Mesomya *et al*. (2009)[217] found a significant decrease in LDL values between rats fed on control diet and others fed on diet contains cooked conventional rice, cooked unpolished organic rice and cooked unpolished conventional rice.

Purushothama *et al*. (1995) [220] found a decrease in LDL-cholesterol level in rats fed on experimental diet containing rice bran and peanut oil.

Shih *et al.* (2007) [194] reported that the high resistant starch in rice reduced serum LDL cholesterol.

Shakib *et al*. (2014) [192] found a significant decrease in serum LDL levels in patients fed on diet contains rice bran oil (RBO) as rice milling industry by-product compared with those fed on baseline diet.

Table (65): Effect of treatment with 5, 10 and 20 % RSMBP on serum low –density lipoproteins-cholesterol (LDL)

Treatment	Control	Treatments		
		5%	10%	20%
LDL (mg/dl)	54.249±9.36445[a]	41.578 ±2.47655[ab]	45.852 ±3.62197[ab]	30.350 ± 2.52594[b]

Values are expressed as means ± S.E

n = 5

[a,b] Means in a row with superscripts without a common letter differ, P <0.05.

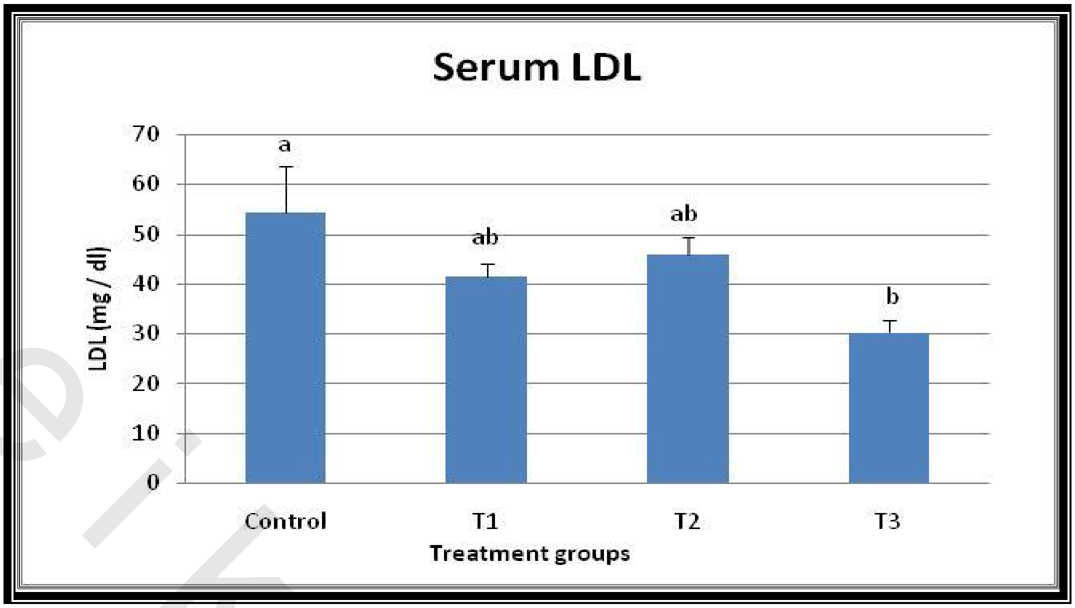

Figure (46): Effect of treatment with 5, 10 and 20 % RSMBP on serum low–density lipoprotein-cholesterol (LDL)

4.5.6.5. Effect on serum high -density lipoprotein- cholesterol (HDL)

HDL form a class of lipoproteins, varying somewhat in their size (8-11 nm in diameter), that carry fatty acids and cholesterol from the body's tissues to the liver. About thirty percent of blood cholesterol form atheroma within arteries and transport it back to the liver for excretion or re-utilization- which is the main reason why HDL-bound cholesterol is sometimes called "good cholesterol" or HDL-C. A high level of HDL-C seems to protect against cardiovascular diseases, and low HDL cholesterol levels (less than 40 mg/dl) increase the risk for heart disease. HDL may hasten the removal of cholesterol from peripheral tissue to the liver for catabolism and excretion. Also, high level of HDL may compete with LDL receptor sites on arterial smooth muscle cells and thus partially inhibit uptake and degradation of LDL. Also, HDL could protect LDL against oxidation *in vivo* because the lipids in HDL are preferentially oxidized before those in LDL (Philip, 2007) [(221)].

Results in Table 66 and Figure 47 showed blood serum content of high –density lipoproteins-cholesterol in control and treated groups. From the results it was found that there was no significant difference between control and treated groups with 5, 10 and 20% RSMBP.

Chemical pathology Reference values for the serum HDL of male albino rats of varied ages ranged from 19.05 to 72.67 mg/dl (Ihedioha et al., 2013) [(219)]

The results are inagreement with Yang *et al.* (2012) [(180)] who found no significant in HDL-cholesterol values between rats fed on control diet and others fed on diet contains rice proteins extraction by classical method with alkaline followed by precipitation with acidic solution (RP-A).

Sharif (2009) [(177)] found no significant in HDL-cholesterol in rats fed on diet contains rice bran as rice industrial by-product compared with rats fed on control diet.

Mesomya *et al*. (2009)[217] found no significant differences in HDL-cholesterol values between rats fed on control diet and other fed on diet contains cooked unpolished organic rice but found significant increase in rats fed on diet contains cooked conventional rice and cooked unpolished conventional rice.

Revilla *et al*. (2009) [211] reported that γ-oryzanol and phenolic compounds which found in brown rice has a greater effect for increasing HDL-cholesterol.

Shakib *et al*. (2014)[192] found a significant increase in serum HDL-cholesterol levels in patients fed on diet contains rice bran oil (RBO) as rice milling industry by-product compared with those fed on baseline diet.

Table (66): Effect of treatment with 5, 10 and 20 % RSMBP on serum high –density lipoproteins-cholesterol (HDL)

Treatment	Control	Treatments		
		5%	10%	20%
HDL (mg/dl)	50.174 ± 3.18614	52.468 ± 2.62989	53.244 ± 3.02711	52.952 ± 3.73209

Values are expressed as Means ± SE
n = 5

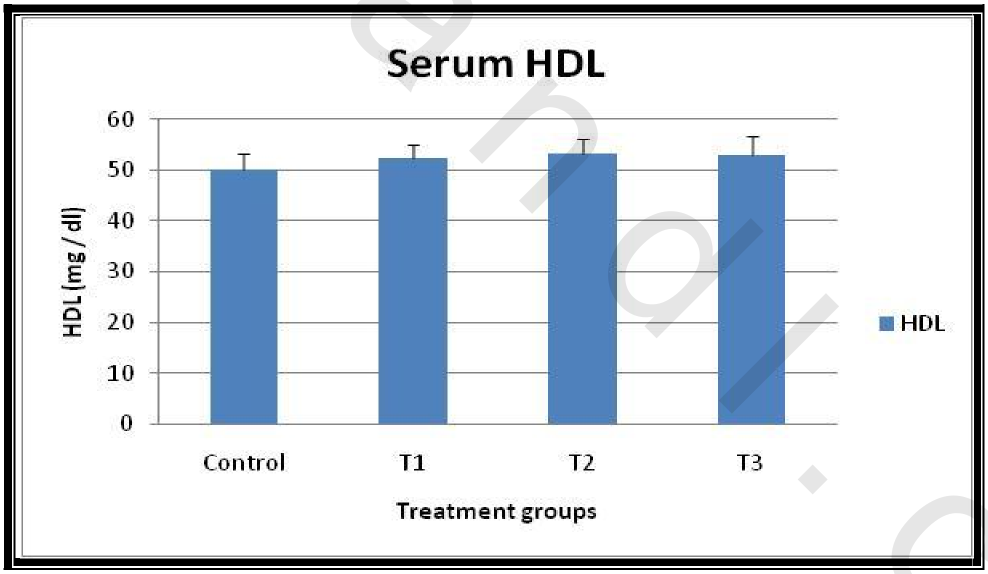

Figure (47): Effect of treatment with 5, 10 and 20 % RSMBP on serum high – density lipoproteins-cholesterol (HDL)

4.5.6.6. Effect on serum very low-density lipoprotein (VLDL)

VLDL is one of the five major groups of lipoproteins made by the liver (chylomicrons, VLDL, low-density lipoprotein, intermediate-density lipoprotein, high-density lipoprotein) that enable fats and cholesterol to move within the water-based solution of the bloodstream and transports endogenous products whereas chylomicrons transport exogenous (dietary) products. It is assembled in the liver from triglycerides, cholesterol, and apolipoproteins. It is converted in the bloodstream to low-density lipoprotein (LDL). VLDL particles have a diameter of 30-80 nm. (Gibbons *et al.*, 2004; Dashti *et al.*, 2011) [222, 223].

Results in Table 67 and Figure 48 showed blood serum content of very low-density lipoprotein (VLDL) in control and treated groups. Results revealed that there was significant ($p < 0.05$) decrease between control and treated group with 20% RSMBP.

Chemical pathology Reference values for the serum VLDL of male albino rats of varied ages ranged from 6.59 to 29.41 mg/dl (Ihedioha et al., 2013) [219].

The results are in agreement with Yang *et al.* (2012)[180] who found a significant decrease in VLDL values between rats fed on control diet and others fed on diet contains rice proteins extraction by classical method with alkaline followed by precipitation with acidic solution (RP-A).

On the other hand, Shakib *et al*. (2014)[192] found a significant increase in serum VLDL levels in patients fed on diet contains rice bran oil (RBO) as rice milling industry by-product compared with those fed on baseline diet.

Table (67): Effect of treatment with 5, 10 and 20 % RSMBP on serum very low-density lipoprotein (VLDL)

Treatment	Control	Treatments		
		5%	10%	20%
VLDL (mg/dl)	28.0775 ± 0.98123[a]	26.8475 ±1.68434[a]	27.9964 ± 1.53761[a]	22.8404±0.86952[b]

Values are expressed as means ± S.E n = 5

[a,b] Means in a row with superscripts without a common letter differ, P <0.05

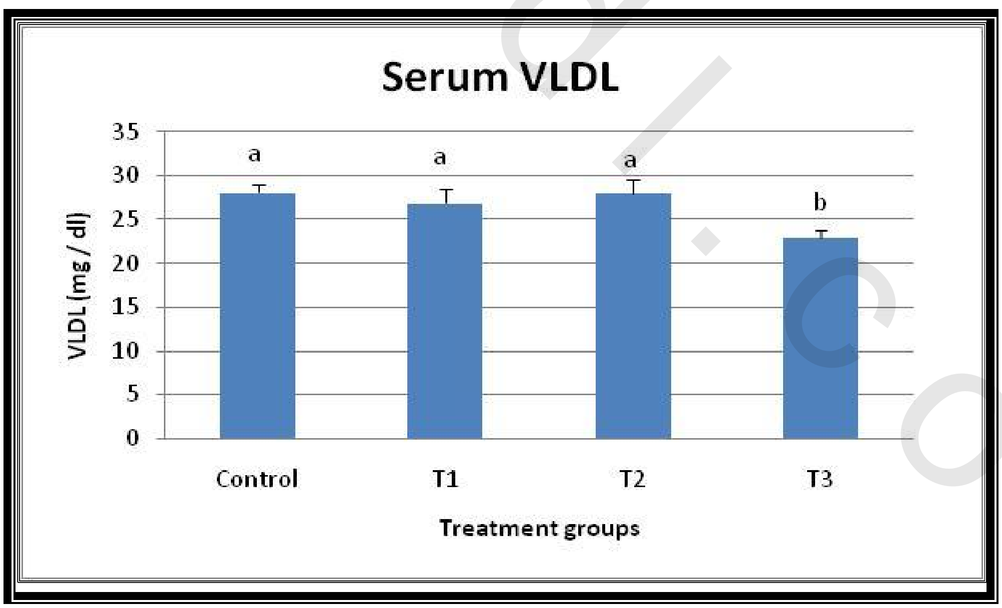

Figure (48): Effect of treatment with 5, 10 and 20 % RSMBP on serum very low-density lipoprotein (VLDL)

4.5.7. Effect on serum thiobarbituric acid-reactive substances (TBARS)

The lipid peroxide Malondialdehyde (MDA) is one of the major end-product of lipid peroxidation process. The determination of MDA content is widely used as a reliable tool to detect the oxidative stress hazard by estimating the formation of lipid peroxides in biological material. Assessments of lipid peroxidation include the analysis of lipid peroxides, isoprostanes, diene conjugates, and breakdown products of lipids such as malonaldehyde, ethane, pentane, and thiobarbituric acid reactive substances (TBARS) (Abuja and Albertini, 2001) [(224)].

Results in Table 68 and Figure 49 showed blood serum content of TBARS in control and treated groups. The results indicated that there was a significant decrease ($p < 0.05$) between control and treated groups with 10, 20% RSMBP.

These results are in agreement with those reported by Sharif (2009) [(177)] who found gradually decreased in thiobarbituric acid with proportionate increase of rice bran oil in cookies formulation in rats diet.

On the other hand, Li *et al*. (2010) [(178)] found no significant differences in TBARS between rats fed on control diet and others fed on diets contain brown rice, rice bran and polished rice.

Table (68): Effect of treatment with 5, 10 and 20 % RSMBP on serum thiobarbituric acid reactive substances (TBARS)

Treatment	Control	Treatments		
		5%	10%	20%
TBARS (mmol/mg protein)	5.7782±1.06750[a]	5.1765±0.10882[a]	3.3540±0.54591[ab]	3.2822±0.20898[b]

Values are expressed as Means ± SE n = 5

[a,b] Means in a row with superscripts without a common letter differ, $P < 0.05$

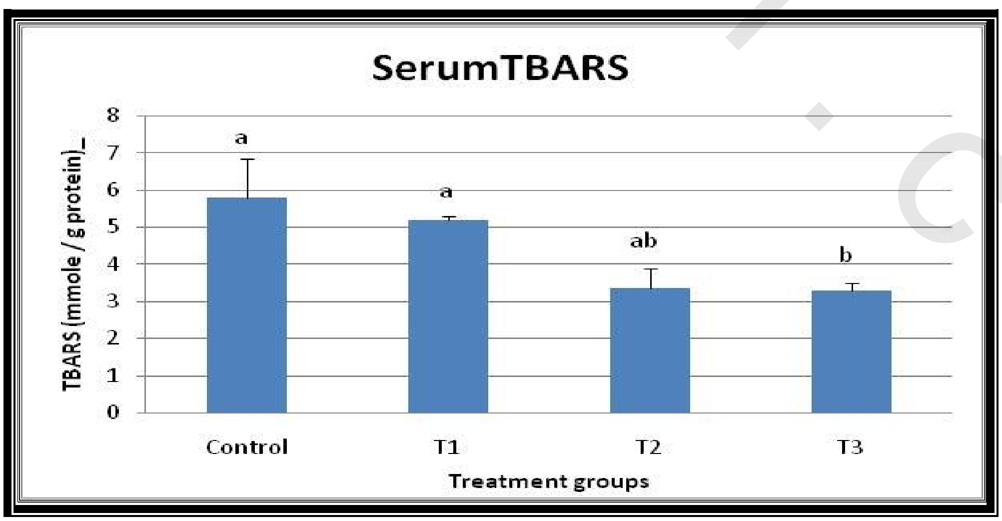

Figure (49): Effect of treatment with 5, 10 and 20 % RSMBP on serum thiobarbituric acid reactive substances (TBARS)

4.5.8. Effect on serum α amylase

α amylases are enzymes which hydrolyze starch molecules to give diverse products including dextrins and progressively smaller polymers composed of glucose units which causes hyperglycemia and development of diabetes mellitus (Shankaraiah and Reddy, 2011)[(225)] . Amylases are enzymes that hydrolyze the carbohydrates into small glucose particles (Windish and Mhatre, 1965) [(226)]. All the alpha amylase enzyme molecules acts on alpha 1-4, 1-6 links of glucose residues (Van der Maarel *et al*., 2002) [(227)]. Amylases were categorized into two, that one is endoamylase and another one is exomylase the endoamylases are involved in hydrolysis of carbohydrates in to different chain lengths of linear and branched molecules and exoamylases reduced in to short molecules (Gupta *et al*., 2003) [(228)]. The enzyme alpha amylase is one of the most important in human body responsible of hydrolysis of starch in to small sugar molecules (Alexander, 1992) [(229)].

Results in Table 69 and Figure 50 showed blood serum activity of α amylase in control and treated groups. The results showed that there was no significant effect between control and treatment groups with 5, 10, 20% RSMBP.

Chemical pathology reference values for male rats of different age groups for amylase, ranged from 128 to 313 IU/dl (Jonson-Delaney, 1996) [(187)]

Table (69): Effect of treatment with 5, 10 and 20 % RSMBP on the activity of serum α amylase

Treatment	Control	Treatments		
		5%	10%	20%
α amylase (IU/dl)	358.889±38.35346	363.3333±23.86950	367.778±21.32928	366.667±35.52950

Values are expressed as means ± SE n = 5

[a,b] Means in a row with superscripts without a common letter differ, P <0.05.

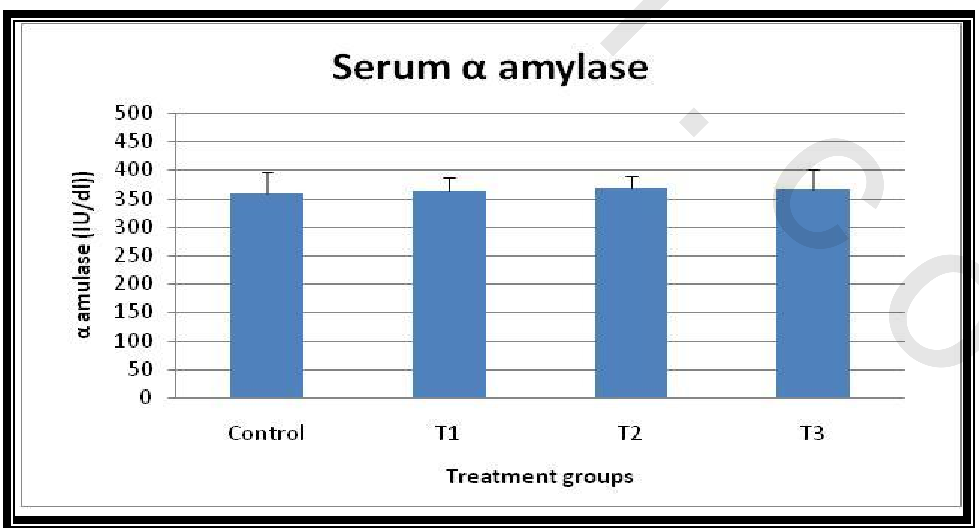

Figure (50): Effect of treatment with 5, 10 and 20 % RSMBP on the activity of serum α amylase

4.5.9. Effect on serum glucose

Results in Table 70 and Figure 51 showed blood serum content of glucose in control and treated groups. From the results it was found that there was no significant effect between control and treated groups with 5, 10, 20% RSMBP.

The values of serum glucose in treatment groups are inagreement with the normal values (50-135) mg / dl (Jonson-Delaney, 1996) [(187)].

The results are inagreement with Um *et al*. (2013) [(182)] who found no significant differences in glucose level between rats fed on diet contained high cholesterol diet with rice protein and other fed on control diet.

On the other hand Yang *et al.* (2012) [(180)] found significant decrease in blood serum glucose between rats fed on control diet and other fed on diet contains rice proteins extraction by classical method with alkaline followed by precipitation with acidic solution (RP-A).

Peter (1992) [(208)] mentioned that high amylose rice have a positive lowering effect on blood glucose levels in humans.

Annison and Topping (1994) [(230)] reported that the foods with more highly resistant starch should yield lower glycemic index values than those with less-resistant starch.

Cheng *et al*. (1994) [(231)] outlined that, high amylose rice products have been found to induce both lower blood glucose compared similar products with higher amylopectin contents.

Kabir *et al.* (1998) [(232)] observed that the consumption of amylose diet for three weeks reduced the postprandial blood glucose response.

Kim *et al*. (2003) [(233)] reported that the resistant starch from rice decreasing tendency in blood glucose concentration.

Izumi *et al*. (2007) [(210)] reported that the fasting blood glucose levels were significantly lower in rats fed 3% milled rice than rats fed polished rice.

Mohamed (2010) [(234)] reported that feeding on rice of high amylose content reduced serum glucose level more than rice of low amylase content.

Table (70): Effect of treatment with 5, 10 and 20 % RSMBP on serum glucose

Treatment	Control	Treatments		
		5%	10%	20%
Glucose (mg/dl)	108.7500 ± 10.56254	118.4500±11.33445	114.1000±11.93272	97.9250±4.74352

Values are expressed as means ± SE

n = 5

[a,b] Means in a row with superscripts without a common letter differ, $P < 0.05$.

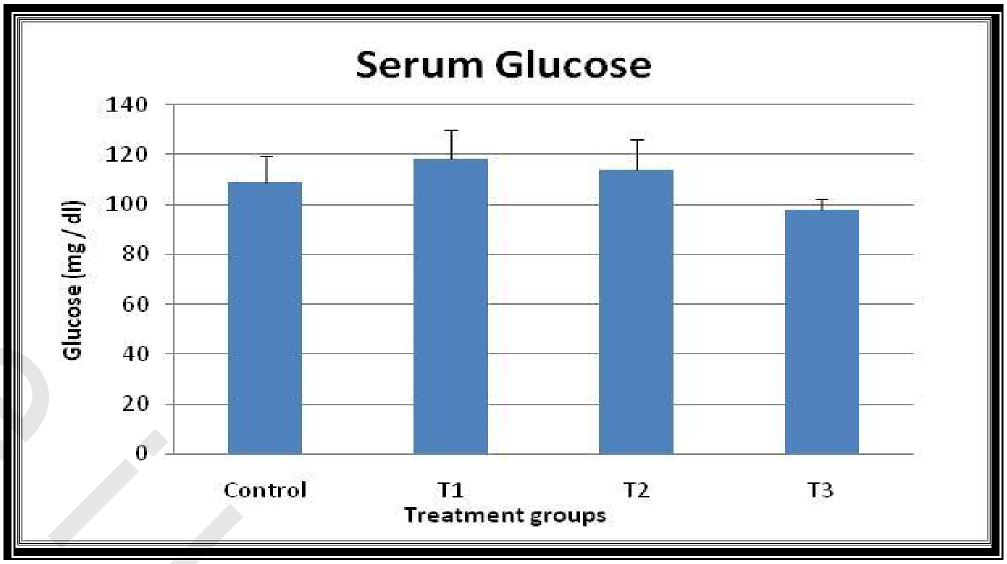

Figure (51): Effect of treatment with 5, 10 and 20 % RSMBP on serum glucose

4.5.10. Effect of treatment with 5, 10 and 20% of rice starch manufacture by-product (RSMBP) on internal organs weight ratio

Results presented in table 71 and Figures (53 and 54) showed that there was no significant effect of treatment on liver and kidney body weight ratio, while there was a significant decrease in heart body weight ratio in all treated groups (5,10 and 20% RSMBP) compared to the control group (Figure 52).

Purushothama *et al*. (1995) [235] found that, rats were fed on experimental diet having 5 and 20% rice bran oil along with peanut oil as control, showed no significant differences with respect to the organ weights between control and experimental groups.

Kim *et al*. (2003) [233] reported that kidneys and liver weights insignificantly differed rats fed on control diet basal and others fed on resistant starch from rice.

Ahmed *et al*. (2007) [181] found non-significant differences in organ weights of rats (liver, kidney, heart) by dietary intake of rice bran either at the 5% or 10% level.

Sharif (2009)[177] found no significant changes in organs weight (liver, heart, lungs, spleen, right and left kidney) in rats fed on diet contains full fat rice bran (FFRB), rice bran oil (RBO), defatted rice bran (DFRB) as rice industrial by-products compared with rats fed on control diet.

Yang *et al*. (2012)[180] reported that diets contain rice proteins extracted from *Oryza sativa L*. by a classical extraction method with alkaline followed by precipitation with acidic solution (RP-A) and other by a method for rice protein isolation by starch degradation using a heat stable α –amylase (RP-A) compared with control diet contains casein protein (CAS) , organs, spleen and kidney, showed the similar weights among the experimental groups. However, the liver weights of rats fed RP-A and RP-E were significantly lower than those fed CAS ($P < 0.05$).

Table (71): Effect of treatment on internal organs weight ratio

Group	Control	Treatments		
		5%	10%	20%
Heart /BW(%)	0.6167±0.01525^{a}	0.5925 ± 0.04064^{ab}	0.5312 ± 0.02551^{b}	0.5996± 0.01888^{ab}
Kidney/BW(%)	1.2696±0.04610	1.3236 ± 0.04803	1.3931± 0.05349	1.2581 ± 0.03126
Liver/BW (%)	5.6433±0.26591	5.3829 ± 0.14664	5.5254± 0.21802	5.3125 ± 0.23299

Values are expressed as Mans ± SE n=10

^{a,b} Means in a row with superscripts without a common letter differ, $P < 0.05$

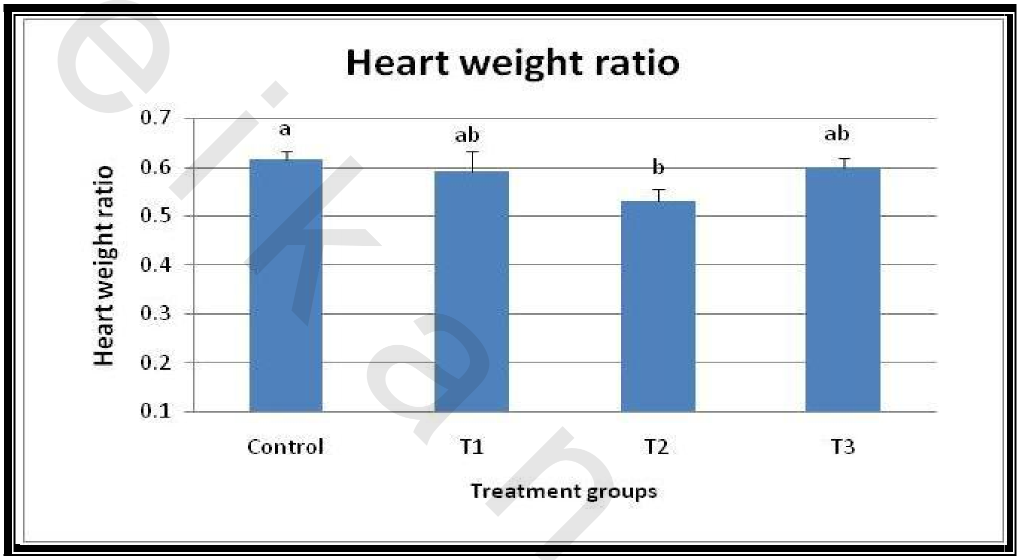

Figure (52): Effect of treatments on heart weight ratio

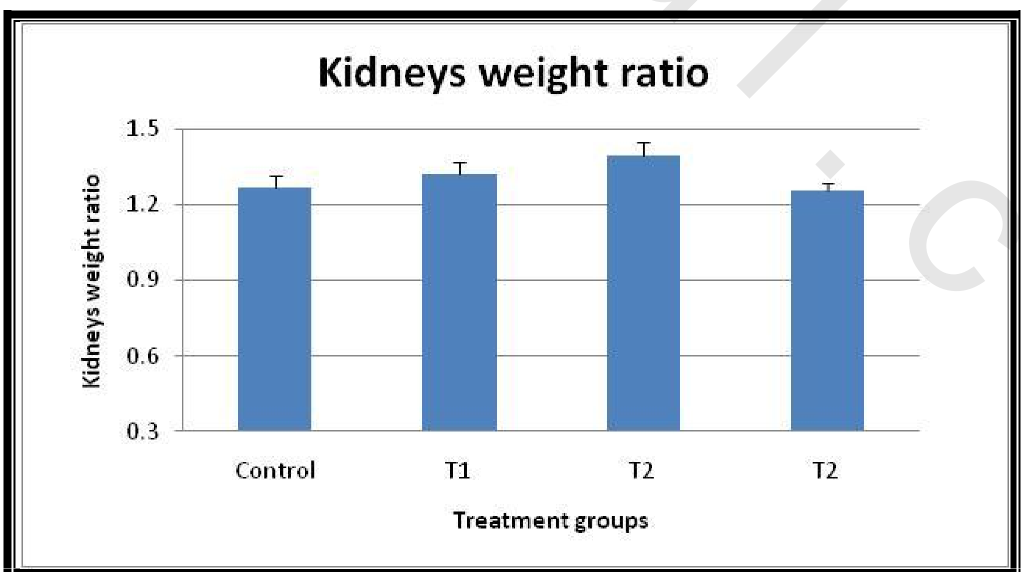

Figure (53): Effect of treatments on kidneys weight ratio

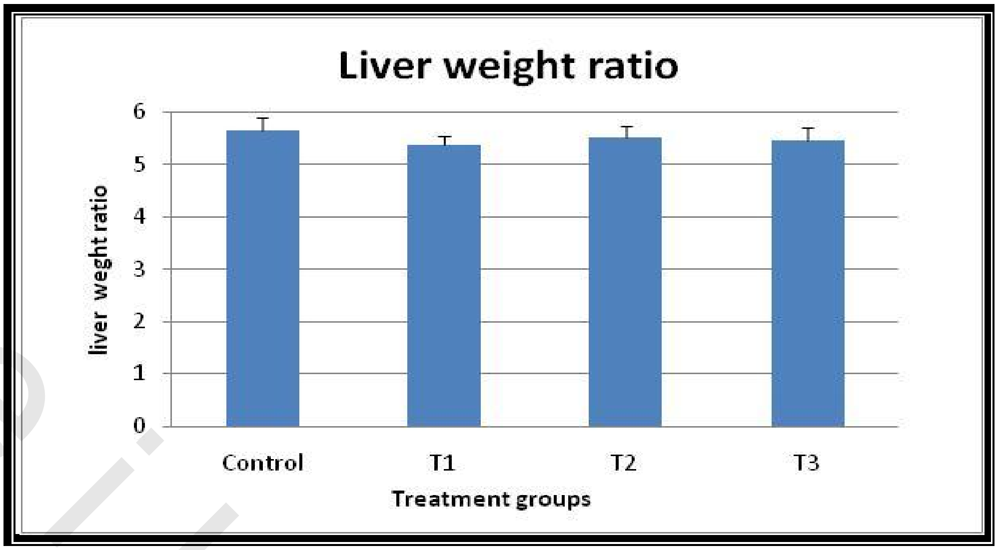

Figure (54): Effect of treatments on liver weight ratio

4.5.11. Effect of treatment with 5, 10 and 20% of rice starch manufacture by-product (RSMBP) on histopathological changes in liver and kidneys

Histopathology is a sensitive tool not only for the detection of low dose effects but also for providing insight into the onset, and mechanism(s) of action. Histopathology provides a rapid method to detect effects of irritants and pathogens in different organs and it can be considered as the indicator for abnormal condition for environment.

4.5.11.1. Liver histology

Liver represents a suitable model for monitoring the effects of a diet, due to its key role in controlling the whole metabolism. The changes in the liver, as a site responsible for biotransformation and detoxification, suggest alterations in the metabolic processes (El-Shamei *et al.*, 2012)[(236)].

Photomicrographs of liver from rats after 8 week of feeding on different experimental diets were illustrated in Figure 55.

Rats fed on control diet showed a normal liver, displayed normal histological structure of hepatic lobules, normal hepatic cells, normal central vein and there is no portal inflammation and normal ratio of cytoplasm and nuclear (Figure 55 (1)).

Rats fed on diet containing 5% RSMBP showed normal hepatic architecture, normal central vein and there is mild inflammation, sinusoidal dilatation and no kupffer cells infiltrating (Figure 55 (2)).

Rats fed on diet containing 10% RSMBP revealed disturbance of hepatic architecture, normal central vein and also showed mild portal inflammation, sinusoidal dilatation and have few infiltrating kupffer cells (Figure 55 (3)). This histopathological change was due to the amylase component of rice but not due to the amount of RSMBP feed.

Rats fed on diet containing 20% RSMBP revealed normal hepatic architecture, normal central vein and there is no portal inflammation, and also showed mild sinusoidal dilatation and have few infiltrating kupffer cells (Figure 55 (4)). The changes was due to a cut inflammation could be reflected normal architecture after metabolism process.

4.5.11.2. Kidney histology

As kidney forms the main organ of excretion the changes noticed are quite prominent. Initial structural changes to the kidney include hypertrophy (increase in cell size) and hyperplasia (increase in cell number). Renal hypertrophy and hyperplasia are structural changes induced by both haemodynamic and metabolic vicissitudes (Magri and Fava, 2009)[(237)].

Photomicrographs of kidney from rats after 8 week of feeding on different experimental diets were illustrated in Figure 56.

The microscopic examination of the kidney sections of rats fed on control diet showed normal histopathological structure of renal parenchyma, normal renal glomeruli. The renal tubules showed no hydropic change and no interstitial inflammation (Figure 56 (1)).

The microscopic examination of the kidney sections of rats fed on diet containing 5% RSMBP revealed normal renal glomeruli, mild wide urinary space and dilated renal tubules (Figure 56 (2)).

The microscopic examination of the kidney sections of rats fed on diet containing 10% RSMBP showed normal renal glomeruli, mild dilating of urinary space surrounded by squamous epithelial cells and interstitial inflammation. Also there is dilating renal tubules, other with hyaline casts in tubules and fewer thickening in blood vessel (Figure 56 (3)). This change may be due to the increased protein in diet.

Rats fed on diet containing 20% RSMBP revealed normal renal glomeruli, surrounded by squamous epithelial cells with no mesangial proliferation in the Glomeruli. The renal tubules showed mild dilation with collected of brush bonder in apical epithelial cells with few inflammatory cell spread between tubules and interstitial area of kidney cortex (Figure 56 (4)). This change was acut histopathological lesion which may be due to recovery affect of wastes protein and urea.

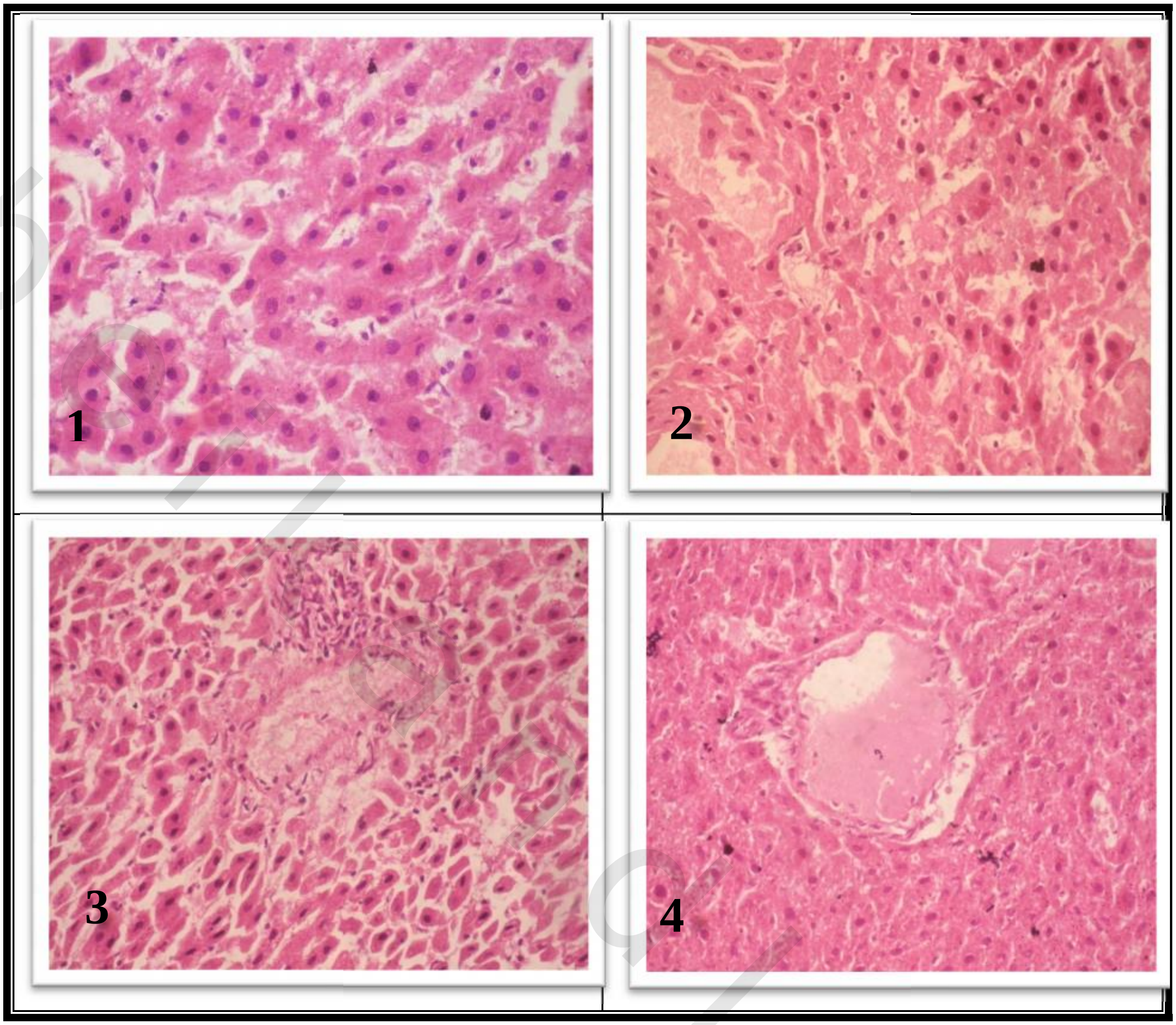

Figure (55): Photomicrograph of liver section of rats (H&H stain, magnification x 200) after 8 weeks of feeding on**:**

1- Control diet showed normal liver, normal central vein and normal hepatic architecture.
2- Diet contained 5% RSMBP showed normal hepatic architecture, normal central vein and also there is mild inflammation and sinusoidal dilatation.
3- Diet contained 10% RSMBP revealed disturbance of hepatic architecture, normal central vein and also showed mild portal inflammation, sinusoidal dilatation and have few infiltrating kupffer cells.
4- Diet contained 20% RSMBP revealed normal hepatic architecture, normal central vein and there is no portal inflammation, and also showed mild sinusoidal dilatation and have few infiltrating kupffer cells.

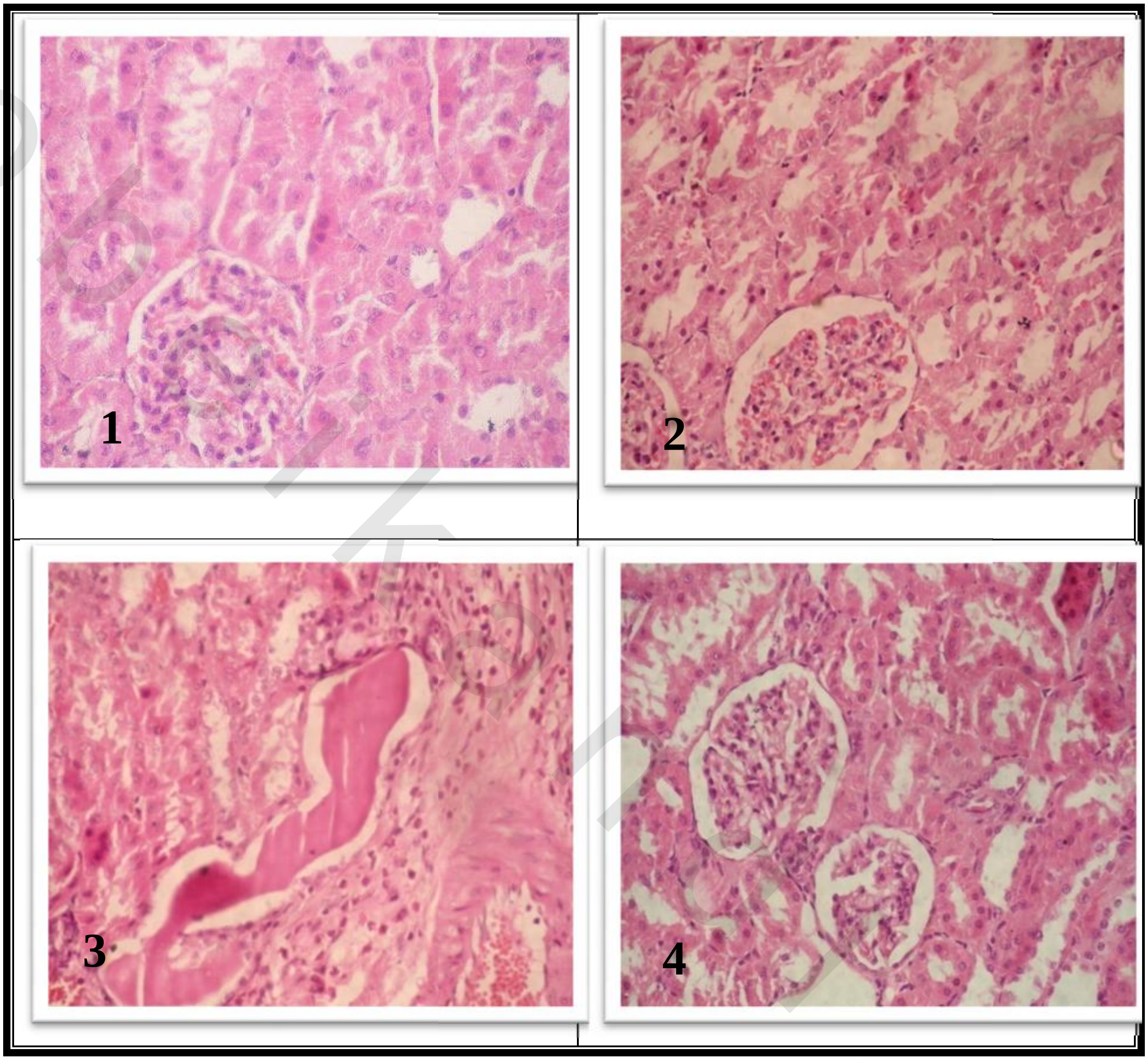

Figure (56): Photomicrograph of kidney section of rats (H&H stain, magnification x 200) after 8 weeks of feeding on:

1- Control diet showed normal renal glomeruli.

2- Diet contained 5% RSMBP revealed normal renal glomeruli, mild wide urinary space and dilated renal tubules.

3- Diet contained 10% RSMBP showed normal renal glomeruli, mild dilating of urinary space surrounded by squamous epithelial cells and interstitial inflammation. Also there is dilating renal tubules, other with hyaline casts in tubules and fewer thickening in blood vessel

4- Diet contained 20% RSMBP revealed normal renal glomeruli, surrounded by squamous epithelial cells with no mesangial proliferation in the Glomeruli. The renal tubules showed mild dilation with collected of brush bonder in apical epithelial cells with few inflammatory cell spread between tubules and interstitial area of kidney cortex.

Summary

5. Summary

- Egyptian Starch, Yeast and Detergent Company (ESYD) is one of the subsidiaries of Food Industries Holding Company, produces starch from broken rice, the production process consumes and discharges large amount of water and wastewater.

- The present work aimed to study water consumption and wastewater generation in rice starch plant and assess the possibility of reducing them for decrease the production cost and separation of proteins and other organic wastes from wastewater and assess the possibility of using organic extracts which containing a high proportion of protein as new by-product for animal feed for raise the company's revenue.

- Broken rice (grade zero and one) was a raw material in starch production in ESYD during the study period; chemical analysis of the two grades showed that there were few differences in the chemical composition between them.

- Water consumption in production processes was 55.5 m^3/ ton broken rice, 4.5 times higher than the standard norms (8-12) m^3 water / ton of raw broken rice and the higher loses was from first centrifuge process which reach to 58. 56 % from the total water consumption, most of this water was used to cool the centrifuge machine (about 300 m^3/ day), it pumped into the centrifuge machine when starch milk stops feeding until refeeding again. Wastewater resulted at rice starch plant was highly COD (around 12500 mg/l), BOD (around 5700 mg/l) and TSS (around 12225 mg/l), it consider valuable waste because its highly content of carbohydrates (around 0.60%) and proteins (around 0.45%) but it was fewer in fats content (around 0.033%) and sodium chloride (around 0.024%).

- By using isoelectric point technique and sedimentation, proteins and other organic wastes were precipitated, followed by centrifuged for separate the sediment from wastewater, and then was dried at 60-70 °C.

- Because wastewater was obtained directly from starch production, the dry separated materials were free in aflatoxines content (*pathogens as Salmonella, Bacillus cereus or staphylococci*).

- The dry separated material was mixed at 5, 10 and 20% to the standard diet and fed rats for 8 weeks under local weather conditions for the city of Alexandria throughout the experimental period.

- The growth performance showed that diet contained rice starch manufacture by-product revealed insignificant effect on body weight gain, feed efficiency ratio and water intake, while a significant increase was observed for body weight gain ratio in all treated groups compared to the control group. On the other hand a significant decrease in feed intake was obtained in all treated groups compared to the control group.

- The effect of treatment on blood hematology parameters showed that there was no significant effect in parameters RBS, Hb, HCT, MCV, MCH, MCHC while there was a significant increase in WBC.

- Serum parameters in treated groups showed that there was no significant effect in parameters TP, Globulin, Albumin, TL, HDL, AST, ALP, α amylase, Urea, Creatinine, Glucose and Bilirubin while there was a significant decrease in parameters Cholesterol, TG, LDL, VLDL, ACP and Uric acid compared to control group and there was a significant increase in ALT between control group and treatment groups with 5 and 20%.

- Internal organs weight ratio showed that there was no significant effect in liver and kidneys weight ratio but there was a significant decrease in heart weight ratio.

- Liver histopathology showed normal hepatic architecture, normal central vein in all treated groups add to there was mild inflammation, sinusoidal dilatation and simple portal inflammation and have few infiltrating kupffer cells in treated group with 10% RSMBP.

- Kidney histopathology showed normal histopathological structure of renal parenchyma, normal renal glomeruli. The renal tubules showed no hydropic change *and* no interstitial inflammations in all treated groups add to there was mild dilating of urinary space surrounded by squamous epithelial cells and interstitial inflammation. Also there is dilating renal tubules, other with hyaline casts in tubules and fewer thickening in blood vessel in treated group with 10% RSMBP.