EFFECTS OF A NEW RECORDED VARIETY OF SUMAC (*RHUS CORIARIA* VAR. *ZEBARIA*) AS DIETARY SUPPLEMENTATION ON GROWTH PERFORMANCE, CARCASS COMPOSITION AND BLOOD PARAMETERS OF COMMON CARP (*CYPRINUS CARPIO* L.) JUVENILES

SALAM RAMADHAN HUSSEIN* and SAMAD SOFY OMAR**
*College of Agricultural Engineering Sciences, University of Duhok, Kurdistan Region-Iraq
**Dept. of Biology Education, Faculty of Education, Tishk International University-Erbil, Kurdistan Region-Iraq

(Received: October 30, 2023; Accepted for Publication: December 24, 2023)

ABSTRACT

This experiment aimed to study the effect of dietary supplement of a new variety Sumac fruit powder (*Rhus coriaria var. zebaria*) with different concentrations on growth performance, serum biochemistry and blood parameters of common carp (*Cyprinus carpio* L.) juveniles. A total of 128 fish juveniles with initial weight (39.38± 0.04 g) stocked randomly distributed into 16 tanks (70 L) at a density of 8 fish for each tank. Fish in 16 tanks were treated with experimental diets at three different concentrations (SFP 0.3%, SFP 0.6%, SFP 0.9%) for 10 weeks. Supplementation SFP 0.3% to the diet significantly (P <0.05) improved most of the studied growth performance traits like weight gain, feed conversion efficiency, protein efficiency ratio, specific growth rate (SGR %) and final body weight with comparing to other groups. However, the lowest value of these parameters recorded in control group. The significant increases in WBC, lymphocytes and monocytes counts observed in SFP 0.3% group (P <0.05). And dietary SFP 0.6% supplementation, significantly (P < 0.05) increased RBC and Hemoglobin. The SFP 0.3% and SFP 0.6% diet received fish, resulted significant (P <0.05) decreases in glucose, total cholesterol, triglycerides and low-density lipoprotein cholesterol.

Keywords: *Rhus coriaria L.*, *Cyprinus carpio L.*, Growth, Hematology and serum biochemistry.

1. INTRODUCTION

Today, fish farming has gained prominence as a source of protein for humans, and is now widely accepted as an important component of the food industry. In order to meet the global protein demand, aquaculture is becoming increasingly important (Hoseinifar *et al*., 2018; Van Doan *et al*., 2018). The role of fisheries and the aquaculture industry is crucial in terms of providing protein to the population, as fish products are considered a significant source of this nutrient. The increase in fish production can be attributed to the development of aquaculture in Asian countries, while the decline in sea fishing is due to over-fishing and the implementation of policy quotas by European authorities in 2013 (Karnai & Szűcs, 2018; Gál *et al*., 2009).

The common carp (Cyprinus *carpio L*) is a freshwater fish species with a long history of farming. It accounts for approximately 3.4% of the world's total fish production and fisheries, equivalent to 4.18 million tons in 2021 (FAO, 2023). Among the world's aquaculture production, carp is ranked third as a significant fish species. Moreover, 97% of its global production comes from aquaculture (Karnai & Szűcs, 2018).

Efforts are underway to find natural alternatives to synthetic compounds that yield similar results. The aim is to identify natural compounds that can act as immune modulators, immune stimulants, bio-productive agents, antioxidants, antimicrobials, enzymatic equipment stimulants, reproduction process controllers (particularly in tilapia fish), and nitrogen absorption stimulants (Van Doan *et al*., 2018; Dzobo, 2022). Research has been conducted on the use of these natural compounds (Galina *et al.*, 2009; Félix *et al.*, 2021; Gabriel, 2019). Sumac (Rhus coriaria L.) is one of the natural products that have been utilized as a medicinal plant for various purposes. It has been found to possess antioxidant, antimicrobial, wound-healing, and immune-stimulant properties (Nasar-Abbas & Halkman, 2004; Kosar *et al*., 2007; Gabr & Alghadir, 2019).

Sumac (*Rhus coriaria* L.) is a shrub that belongs to the Anacardiaceae family. It serves both as a spice and traditional medicine and grows wild from the Canary Islands across the Mediterranean coast (Diler *et al*., 2021b). Indigenous communities have employed it for various medicinal and practical purposes over the years. *Rhus coriaria* has been identified with antibacterial properties, antifungal capabilities (Onkar *et al*., 2011), antioxidant benefits (Aliakbarlu *et al*., 2014) and anti-inflammatory effects (Panico *et al*., 2009). Sumac berries are rich in phenolic acids, flavonols, hydrolysable tannins, anthocyanin, and organic acids (Mavlyanov *et al*., 1997). Numerous bioactive compounds present in sumac include gallic acid, quercetin, and vanillic acid (Al-Boushi *et al*., 2014). *R. coriaria var. zebaria* is a new variety of *R. coriaria* shrub and belong to the Anacardiaceae family was documented in Iraq, specifically in the Kurdistan Region by (Shahbaz & Abdulrahman, 2014).

Feeding sumac to fish has been found to enhance their immune responses, improve fish resistance to diseases, enhance hematological indices, improve the morphology of intestines, increase the activity of superoxide dismutase in fish muscles, reduce mortality rates associated with *Vibrio-anguillarum* infection in rainbow trout and improved growth traits (Gharaei *et al* 2020; Diler *et al*., 2021a; Diler *et al*., 2021b). In a study on experimental periodontitis, the use of an ethanol extract of sumac in rats resulted in a reduction in periodontal inflammation, expression of receptor activator of nuclear facto-kappa B ligand (RANKL), alveolar bone loss, and levels of total oxidant status (TOS) and oxidative stress index (OSI). Additionally, it increased the expression of osteoprotegerin (OPG) (Sağlam *et al*., 2015).

The aim of this research is to study the effect of feed containing different concentrations of (*Rhus coriaria var. zebaria*) a new recorded whitish-fruited variety of Sumac on growth performance, carcass composition and blood parameters of *C. carpio* juveniles.

2. MATERIALS AND METHODS

2.1. Experimental System and Design

This study was carried out in close recirculation system at the Fish Laboratory, College of Agricultural Engineering Science, University of Duhok, Iraq. The fish for this study were obtained from Tarjan commercial fish farm in Erbil, Kurdistan Region-Iraq. An acclimation period 21 days was applied prior to the trail and fed with basal diet. A total of 128 common carp (*Cyprinus Carpio* L.) juveniles were cultured in this experiment, with an average weight of (39.38± 0.04 g), were randomly distributed into 16 tanks with a capacity of 70 L. Eight fish stocked in each tank. To ensure optimal aeration and water circulation within the tanks, individual water inlets and Hailea ACO-318 air compressors with a flow rate of 75 L/min were provided. Throughout the experiment, daily measurements of water quality parameters, including average water temperature (24.5±2.5 °C), dissolved oxygen (DO) levels (6±1 mg/L), and pH (8±0.4), were taken. These measurements consistently remained within acceptable ranges for promoting normal fish growth, as indicated by Boyd and Tucker (2012). Additionally, to maintain a clean environment and eliminate waste, a daily vacuum procedure was implemented, ensuring a controlled and consistent environment for the common carp's juveniles throughout the study.

2.2. Diet formulation

Sumac seed obtained from Duhok-Akre local marked and powdered by blinder. Four experimental diets formulated, the proximate composition of diet ingredients was determined, three diets contained Sumac fruit powder (SFP) with different concentration (SFP 0.3%, SFP 0.6%, SFP 0.9%), and first diet for control groups made from same feed ingredients, free from Sumac. Then added water to prepared mixtures to make fine dough and passed through a meat grinder machine to obtain a standard pellet with 2-mm in diameter. Pellets dried at room temperature for five days, big particles crushed finely by Kenwood, produced uniform pellet particles, and stored at the room temperature. During the first week, the fish were fed experimental diets equal to 2.5% of their body weight, twice daily at 9:00 a.m. and 2:00 p.m. Their weights were measured weekly to calculate feeding percentages.

Table (1): Formulation of experimental diets and proximate analysis

	Basic diet	Experimental diets		
Ingredients				
soybean meal (g) [a]	570	570	570	570
Corn (g) [b]	122	122	122	122
Fishmeal (g) [c]	100	100	100	100
sunflower oil (g) [d]	45	45	45	45
Wheat flour (g) [e]	100	97	94	91
Wheat bran (g) [f]	13	13	13	13
PRIMIX (g) [g]	50	50	50	50
Sumac seed powder (g) [h]	0	3	6	9
Feed Ratio formulation (g)	1000	1000	1000	1000
Proximate analysis				
Dry matter %	95.06	94.36	94.27	93.77
Crude protein %	33.42	32.72	32.63	33
crude lipid %	1.94	2.52	2.63	2.78
Crude fiber %	2.75	3	3.2	3.4
Crude ash %	9.6	10.4	10.8	11.83
Net. Energy (kcal/kg)	2992	2960	2939	2888

[a]Soybean obtained from Amidi local Company and originally sourced in Argentina
[b]Corn obtained from Amidi local company and sourced from Besler Company in Turkey
[c]Fish meal obtained from Bay Sky local company sourced in EUROSTAR in Turkey
[d]Sunflower oil obtained from local marked sourced in Zer Group in turkey
[e]Wheat flour obtained from Cihan local Company and originally sourced in Kurdistan region, Iraq.
[f]Wheat bran obtained from Cihan local Company and originally sourced in Kurdistan region, Iraq.
[g]PRIMIX (vitamins+minerals): Obtained from BAYSKY local company and originally sourced in EUROSTAR in Turkey, Vitamin premix contained the following per 10 kilogram; 400000 IU vitamin A, 200000 IU vitamin D3 , 1000 mg vitamin E, 80 mg vitamin B12, 70 mg vitamin B6, 2000 mg Niacin, 4000 mg Iron . 4000 mg manganese, 4000 mg zinc, 2000 mg copper, 60 mg cobalt, 50 mg iodine, 300 mg Aroma, 2400 mg manganese ox. 2000 mg Sodium bi car . 3000 mg Antioxidant, 3000 mc,g L.lysine. 2000 mc,g DL-Methionine
[h]Sumac seed obtained from Duhok-Akre's local marked and originally sourced in Kurdistan region, Iraq.

2.3. Assessment of Growth Performance and Feed Utilization

After ten-week feeding period, the following growth performance and feed utilizations are measured:

- Weight gain (g/fish) = Final Wt (W2)-Initial Wt (W1).
- Specific growth rate (SGR %) was calculated as follows:

SGR % = (Final body weight-Initial body weight) /T (experimental period) x100

- Feed conversion ratio (FCR) = (Total feed intake, g)/ (Total wet weight gain, g).
- Total feed intake (TFI, g)
- Protein efficiency ratio (PER) was calculated as follows:

-PER = (Total weight in wet, g/ fish) / (administered protein amount, g/ fish).

-PI = feed intake x protein content in the diet

2.4. Proximate composition

Before starting the experiment, eight fish were randomly selected and dried to analyze the initial body proximate composition. At the end of the experiment, 32 fish, two fish from each replicate tank randomly taken and dried (oven with temperature 105 ℃, time 72 H) for whole body chemical analysis (moisture, crude protein, crude lipid, ash and net Energy) and all diets were analyzed for proximate composition at Barash feed company lab, Erbil.

2.5. Blood Examination

At the end of the experiment, two fish were randomly selected from each replicate tank for blood examination. Fish were anesthetized using 5% clove powder, and blood samples were taken from the caudal vein. Complete blood count (CBC) tests were conducted, with heparinized vials used for blood storage to prevent coagulation. Serum biochemistry analysis involved centrifuging the blood samples at 3000 rpm for 5 minutes to separate the serum.

Blood count parameters included leukocyte count (WBC, lymphocytes, monocytes, and granulocytes), as well as the percentage of lymphocytes, monocytes, and granulocytes. Erythrocyte parameters consisted of red blood cell count (RBC), hemoglobin (HGB), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV), hematocrit (HCT), platelet count (PLT), red cell distribution width-standard deviation (RDW-SD), red cell distribution width-based on both the distribution curve and the mean cell size (RDW-CV), procalcitonin (PCT), mean platelet volume (MPV), platelet distribution width (PDW), and platelet-large cell ratio (P-LCR). These parameters were measured.

Serum biochemical parameters included glucose, cholesterol (CHO), triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), globulin (Glob), albumin (ALB), total protein (TP), alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), urea, and creatinine. Blood parameters and serum biochemical were measured using an automatic hematology analyzer BC-2800 (laboratories of College of Agricultural Engineering Sciences, University of Salhaddin-Erbil).

2.6. Statistical analysis

The results of this study were expressed as mean ± standard error (SE). All statistical analysis (Growth performance, body composition, haemato-biochemical indices) was performed to one-way ANOVA, using SPSS program (Statistical package for social sciences, version 26, IBM Company 2019). Differences between treatments means were compared by Duncan multiple range test and at $P < 0.05$.

3. RESULTS

3.1 growth performance and feed utilization

The groups that were fed a diet supplemented with SFP at 0.3% and 0.6% recorded significant improvements in most of the studied growth performance parameters, including total feed intake, feed conversion ratio, feed conversion efficiency, protein efficiency ratio, specific growth rate, weight gain, and final body weight, when compared to the control group. However, the control group recorded the highest mean value in protein intake as shown in Table 2. Furthermore, SFP dietary supplementation at 0.9% showed no significant differences in Specific growth rate and total feed intake when compared to the control group.

Table (2): Growth performance and feed utilization of the common carp (*Cyprinus carpio* L.) juveniles fed diets with sumac (*Rhus coriaria* var. *zebaria*) fruit powder.

Parameters	Control	SFP 0.3%	SFP 0.6%	SFP 0.9%
IBW	39.41±0.07	39.35±0.13	39.36±0.06	39.38±0.05
FBW	$60.84{\pm}0.18^{d}$	$64.04{\pm}0.165^{a}$	$61.85{\pm}0.07^{b}$	$62.00{\pm}0.32^{c}$
WG	$21.43{\pm}0.24^{d}$	$24.69{\pm}0.10^{a}$	$22.49{\pm}0.06^{b}$	$21.88{\pm}0.06^{c}$
SGR	$0.72{\pm}0.01^{c}$	$0.81{\pm}0.003^{a}$	$0.75{\pm}0.002^{b}$	$0.74{\pm}0.001^{c}$
TFI	$432{\pm}0.57^{b}$	$436{\pm}0.63^{a}$	$433{\pm}0.14^{b}$	$433{\pm}0.27^{b}$
FCR	$2.52{\pm}0.03^{a}$	$2.21{\pm}0.01^{d}$	$2.41{\pm}0.01^{c}$	$2.48{\pm}0.01^{b}$
FCE	$39.63{\pm}0.40^{d}$	$45.27{\pm}0.12^{a}$	$41.53{\pm}0.01^{b}$	$40.39{\pm}0.12^{c}$
PI	$144.59{\pm}0.19^{a}$	$142.76{\pm}0.21^{b}$	$141.33{\pm}0.47^{c}$	$143.01{\pm}0.09^{b}$
PER	$1.19{\pm}0.012^{d}$	$1.39{\pm}0.003^{a}$	$1.28{\pm}0.002^{b}$	$1.22{\pm}0.003^{c}$

Data in the same row with different subscripts are significantly different ($P \leq 0.05$), Data are presented as mean ± SE. IBW; Initial Body Weight, FBW; Final Body Weight, WG; Weight Gain, SGR; Specific Growth Rate, TFI; Total Feed Intake, FCR; Feed Conversion Ratio, FCE; Feed Conversion Efficiency, PI; Protein Intake, PER; Protein Efficiency Ratio.

3.2 proximate analyses

For the proximate analysis of whole dried fish, no significant differences were observed in the effects of the feed treatments on lipid, crude ash, and crude fiber content. The mean value of crude protein was lowest in group that received SFP0.9% as a dietary supplement, compared to control group; however, no significant differences were reported. The mean value of moisture content was lower in group that received SFP0.6% but not significant differences were recorded. The energy means were higher in group that treated with SFP dietary supplement at 0.9% without any significant differences (Table 3).

Table (3): Whole body composition of the common carp (*Cyprinus carpio* L.) juveniles fed diets with sumac (*Rhus coriaria* var. *zebaria*) fruit powder.

Parameters	Control	SFP 0.3%	SFP 0.6%	SFP0.9%
Moisture (%)	75.77±0.32	75.07±0.82	70.64±1.17	75.51±0.90
Protein (%) *	51.78±0.51	54.85±0.86	54.86±1.39	51.09±1.47
Lipid (%)*	27.41±1.42	25.43±2.15	25.93±1.72	29.57±1.10
Ash (%) *	9.70±0.21	10.25±0.73	9.30±0.15	9.44±0.41
Fiber (%) *	0.44±0.07	0.36±0.10	0.41±0.03	0.42±0.02
Energy (kcal/kg)	4331±29.61	4260±30.76	4307±30.31	4479±28.60

Data in the same row with different subscripts are significantly different (P≤0.05).
Data are presented as mean ± SE.
* Dry matter basis

3.3 blood parameters

Dietary supplementation with SFP0.3% significantly increased mean values of WBC, lymphocytes, monocytes, and granulocytes compared to the control group. Furthermore, the mean values of Erythrocyte-red blood cells count, hemoglobin, mean of corpuscular hemoglobin concentration, mean corpuscular hemoglobin and hematocrit test in the supplementary diets are higher than the means values recorded in the control diet. Additionally, dietary supplementation with SFP at different levels did not produce any significant effects on mean corpuscular volume in comparison to the control group (Table 4).

Table (4): Hematological parameters of the common carp (*Cyprinus carpio* L.) juveniles fed diets with sumac (*Rhus coriaria* var. *zebaria*) fruit powder.

Parameters	Control	SFP 0.3%	SFP 0.6%	SFP 0.9%
WBC ($\times 10^9$/L)	23.75 ± 1.44^c	56.00 ± 2.27^a	36.25 ± 1.31^b	24.50 ± 1.94^c
Lymphocytes ($\times 10^9$/L)	14.5 ± 0.96^c	34.8 ± 3.57^a	27.5 ± 2.40^b	15.5 ± 0.65^c
Monocytes ($\times 10^9$/L)	1.72 ± 0.13^c	4.82 ± 0.38^a	2.66 ± 0.15^b	2.29 ± 0.04^{bc}
Granulocytes ($\times 10^9$/L)	8.6 ± 0.11^d	14.5 ± 0.16^a	9.8 ± 0.11^c	11.9 ± 0.43^b
RBC ($\times 10^{12}$/L)	20.56 ± 0.928^d	25.99 ± 0.71^c	35.25 ± 0.9^a	29.48 ± 1.01^b
HCT (%)	30.96 ± 0.82^d	37.99 ± 0.22^c	52.32 ± 0.39^a	45.98 ± 2.58^b
HGB (g/L)	11.77 ± 1.00^c	15.98 ± 0.53^b	23.05 ± 1.91^a	21.83 ± 1.11^a
MCH (P g)	34.80 ± 4.0^b	37.83 ± 1.4^{ab}	39.99 ± 2.2^{ab}	44.38 ± 1.2^a
MCHC (g/L)	37.8 ± 4.09^b	44.5 ± 2.02^{ab}	44.5 ± 2.33^{ab}	47.8 ± 1.70^a
MCV (f L)	90.43±3.5	84.55±1.8	89.08±1.9	91.15±4.0

Data in the same row with different subscript are significantly different (P≤0.05).
Data are presented as mean ± SE.

The studied serum lipid profile indicates that the groups receiving SFP as a dietary supplement at 0.3% and 0.6% displayed significant decreases in triglycerides and low-density lipoprotein levels in comparison to the control group. Moreover, the high-density lipoprotein had the lowest mean value in the control group. Additionally, the total serum cholesterol and glucose levels in both the groups supplemented with 0.3% and 0.6% SFP were exhibited significant decreases compared to the control group and SFP0.9% group. As for serum globulin, albumin, and total protein, the SFP groups exhibited higher mean values compared to the control group. The control group had the highest mean values for alkaline phosphatase, aspartate aminotransferase, alanine aminotransferase, urea, and creatinine when compared to the treated groups with SFP (Table 5).

Table (5): Serum biochemical parameters of the common carp (*Cyprinus carpio* L.) juveniles fed diets with sumac (*Rhus coriaria* var. *zebaria*) fruit powder.

Parameters	Control	SFP 0.3%	SFP 0.6%	SFP 0.9%
TG (mg/dL)	267±4.87[a]	241±1.58[c]	219±1.03[d]	251±1.29[b]
CHO (mg/dL)	137 ± 0.65[a]	123±0.91[b]	113±0.65[c]	135±0.65[a]
HDL (mg/dL)	10.25±0.63[b]	14.0±0.41[a]	13.75±0.63[a]	14.50±0.29[a]
LDL (mg/dL)	7.75±0.96[a]	5.75±0.96[b]	5.50±0.58[b]	7.75±0.96[a]
Glucose (mg/dL)	193.75 ± 1.75[a]	178.75 ± 1.38[b]	167.25 ± 1.11[c]	192.25 ± 1.93[a]
Glob (g/dL)	2.04±0.02[c]	2.15±0.01[b]	2.31±0.02[a]	2.31±0.01[a]
ALB (g/dL)	1.10±0.01[c]	1.20±0.01[b]	1.26±0.01[a]	1.23±0.01[a]
TP (mg/dL)	3.13±0.01[c]	3.35±0.01[b]	3.57±0.02[a]	3.54±0.02[a]
AST (IU/L)	2838±56.6[a]	1654±20.6[c]	1497±22.3[d]	1912±31.2[b]
ALT (IU/L)	173.5±3.12[a]	136.0±1.87[b]	143.0±2.35[b]	122.8±2.06[c]
ALP (IU/L)	120.5±1.55[a]	71.75±4.96[c]	61±5.08[c]	85.75±1.65[b]
Urea (mg/dL)	7.25±0.63[a]	5.75±0.48[b]	5.25±0.25[b]	5.00±0.00[b]
Creatinine (mg/dL)	0.18±0.04[a]	0.05±0.01[b]	0.04±0.002[c]	0.05±0.01[b]

Data in the same row with different subscripts are significantly different (P≤0.05).
Data are presented as mean ± SE.

4. DISCUSSIONS

Recently, there has been a significant emphasis on utilizing natural immuno-stimulants in aquaculture to combat diseases and minimize the reliance on potentially harmful antibiotics (Hai, 2015). As a result, the prospect of employing herbs and spices as viable substitutes for antibiotics in fish culture has gained considerable attention (Carbone and Faggio, 2016; Aragona *et al*., 2018; Nath *et al*., 2019). Various studies conducted previously, that the administration of sumac into trout diet leads to enhanced immunity, haematopoesis, and improved survival rates (Gharaei *et al*., 2020) with no significant impact on growth performance (Shafiei, 2017).

In the current study, supplementation of SFP0.3% in the diet of *C. carpio* juveniles yielded significant improvements in several growth performance parameters, such as FI, FCR, WG, FCE, PER, SGR, and FBW. Increasing feed consumption could be attributed to the fish heightened demand for nutrients during the growth phase, as well as an increased appetite stimulated by the presence of sumac in their diet, due to the presence of bioactive compounds in sumac fruit (Toghyani & Faghan, 2017). These findings disagree with those of other research. For instance, studies involving rainbow trout (*O. mykiss*) (Shafiei, 2017), as well as broilers (Golzadeh *et al*., 2012; Cakmak *et al*., 2017), that were fed diets containing SFP did not yield significant changes in their growth parameters. On the other hand, the results were in agreement with the findings of a recent study by Diler *et al*. (2021a) demonstrated that SFP supplementation at a rate of 0.5% to the diet had a positive effect on FBW of rainbow trout (*O. mykiss*). Moreover, the current research revealed that the SFP0.3% supplementation had a positive effect on most of the growth performance parameters of *C. carpio*

(P < 0.05). Similarly, several other researchers have reported that supplementation of sumac fruit or sumac extracts into the diet of broiler chickens improved their growth performance (Mansoub, 2011; Ghasemi et *al*., 2014; Valiollahi *et al*., 2014). The growth-enhancing effects of sumac can be attributed to its composition of phenolic compounds (Ozkan *et al*., 2010; Mahdavi *et al*., 2018), vitamins, minerals, essential oils, aromatic substances, carbohydrates, amino acids, proteins, and lipids (Kossah *et al*., 2009), all of which have digestive and stimulatory properties. Sumac's phenolic compounds are diverse; these compounds have been found to exhibit antioxidant, antimicrobial, anti-inflammatory, and anticarcinogenic activities, and positively impact the overall performance and immunity of fish, ultimately improving their health status and production (Nasar-Abbas & Halkman, 2004; Kosar *et al*., 2007; Gabr & Alghadir, 2019; Ahmadifar *et al*., 2021; Diler *et al*., 2021a). Furthermore, according to Ghasemi *et al*. (2014) the enhanced growth and feed efficiency observed in broiler chicks can be attributed to the presence of bioactive substances (cinnamaldehyde and eugenol) found in sumac. These compounds lead to improved feed utilization, ultimately promoting more efficient growth. All mentioned novel compounds can be possible reasons of SFP positive effects on current study's results.

The current study did not reveal any positive significant differences in the proximate analysis parameters of the whole dried fish, including lipid, protein, fiber, ash, and moisture percentages in all dietary treatments. Similarly, in other related investigations, Yousefi *et al*. (2019) found that rosemary powder had no significant effect on the protein, lipid, and moisture content in common carp juveniles when fed with different levels of rosemary leaf powder (RLP). However, In contrast to the results of present study , Hassan *et al*. (2018) found significant differences (p < 0.05) in the proximate composition among the experimental groups when Nile tilapia fed with 1% of turmeric resulted significantly higher (P < 0.05) crude protein levels compared to the control group, the moisture and crude lipid content were significantly lower (P < 0.05). Also, another study investigated that supplementation of sour amla (*Phyllanthus emblica*) fruit powder at a 3% level in the diets of Indian major carp (*Labeo rohita*) fingerlings demonstrated a significant (p < 0.05) increase in the proximate analysis parameters of fish body composition, including total protein, total lipid, total carbohydrates, and ash content (Abbasi Ghadikolaei *et al*., 2017). However, in the current study, it was observed that the mean energy content was higher in the group fed with SFP 0.9% without causing significant differences when compared to control group.

Hematological parameters are viewed as markers of fish health (Faggio *et al*., 2016; Seibel 2021; and Rebl, 2021). Blood cells such as erythrocytes, leukocytes, lymphocytes, monocytes, and granulocyte provide important information in evaluating the health of fish, as confirmed by previous studies such as Fazio *et al*. (2015) and Burgos-Aceves *et al*. (2018). In the current study the significant (p < 0.05) increases in WBC, LYM, MON and GRA counts observed in common carp fed a diet supplemented with SFP0.3%, suggests that sumac may have the ability to enhance the fish non-specific immune response. The immune-stimulating properties of sumac polysaccharides, which are large molecules with antigenic properties, may be involved in this response. Our findings agree with earlier research by Gharaei *et al*. (2020) when fed rainbow trout (*O. mykiss*) with 2% and 5% of sumac supplementation. Furthermore, Choudhury and Nimbalkar *et al*. (2005) and Thanikachalam *et al*. (2010) have noted that the elevation of WBC count in fish can be achieved through the supplementation of natural immunostimulants such as sumac, garlic, ascorbic acid, and beta-glucan in their diet. On the other hand, the observed increase in RBC count in our study, attributed to sumac consumption, could potentially be linked to its capacity to stimulate the kidneys into releasing erythropoietin, a hormone responsible for initiating red blood cell production (Gharaei *et al*., 2020). The membranes of red blood cells contain a substantial concentration of polyunsaturated fatty acids, rendering them susceptible to peroxidation instigated by free radicals. This susceptibility might lead to hemolysis caused by the peroxidation of membrane lipids (Gharaei *et al*., 2020). Antioxidants play a crucial role in neutralizing free oxygen radicals and maintaining the stability of red blood cell membranes (Pham-Huy *et al*., 2008). Sumac is acknowledged for its robust antioxidant capabilities, attributed to its polyphenolic compounds, particularly gallic acid and its derivatives (Najjar *et al*., 2017). In this study, supplementation of SFP0.6% significantly elevated the RBC count, similar to previous research by Gharaei *et al*. (2020). Studies have provided evidence of sumac efficacy in protecting red blood cell membranes from hemolysis. Consequently, the observed increase in RBC count in our study can be attributed to sumacs antioxidant properties, which prevented the breakdown of red blood cells, consistent with the findings in Gharaei *et al*. (2020) study. Our results were disagree with the findings of Diler *et al*. (2021b), it was observed that supplementing sumac fruit powder at different levels had no significant impact on the RBC count of rainbow trout (O. *mykiss*) juveniles. Regarding the other hematological parameters investigated in this study, the supplementation of SFP0.6% in the diet led to a notable increase in Hb, HCT, MCH and MCHC compared to the control group. These findings are in contrast with the results of previous research conducted by Diler *et al*. (2021b), who examined the effects of sumac fruit powder supplementation in the diet of rainbow trout (*O. mykiss*) and found that no significant effects were observed in the HC, Hb, MCH, and MCHC. As a result, our observations in the current study in contrast with the results obtained by other researchers, where rainbow trout treated with *Origanum vulgare* extract (Haghighi and Rohani, 2015) and carvacrol powder (Ahmadifar *et al*., 2021) exhibited no significant differences in RBC, Hb, MCV, MCH, and MCHC parameters in fish. In contrast in the present study MCV were no adversely affected in fish feeding with SFP supplementary diets when compared control group.

In the current study, diet formulation with SFP0.6% caused to decrease in glucose, TG, CHO, and LDL levels ($P < 0.05$) in fish blood serum, while the HDL levels slightly increased in treatment groups compared to the control group. The polyphenolic components found in Sumac are linked to its ability to lower cholesterol levels. Our results were in line with findings of Kheiri *et al*. (2015), who mentioned that a diet that includes Sumac at a concentration of 0.02% can lead to decreased levels of TG, CHO, and LDL in the plasma of female broiler chicks at 42 days. Our results disagreed with the previous study conducted by Diler *et al*. (2021a), which demonstrated that supplementing SFP with various levels to the diet had no significant impact on the glucose and lipid profile (TG, CHO, LDL, and HDL) of rainbow trout (O. *mykiss*) among the experimental groups. Elevated glucose levels in combination with low protein levels are recognized as markers of stressful conditions, but both can be utilized as sources of energy to counteract stress (Barton, 2002; Seibel *et al*., 2021). Urea, creatinine and transaminases such as AST and ALT, are involved in the metabolism of proteins and amino acids, and may be released into the bloodstream in response to tissue damage or malfunction (Diler *et al*., 2021a). In current study, different levels of Sumac supplementation to the diet had a positive impact on the modified biochemical parameters. This indicates that SFP supplementation into the diet was effective in reducing the levels of Urea, creatinine, AST, ALT, ALP and glucose in fish. In contrast to the current study, the dietary levels of onion powder did not have a significant impact on the ALT, AST, and ALP levels in juvenile beluga *Huso huso*, except for the AST level in *H. huso* fed with 1% dietary onion powder (Akrami *et al*., 2015).

In the present study, TP and ALB found a significant increase with a diet of SFP0.6% supplementation when compared to the control group. Measuring the levels of total protein, albumin, and globulin can indicate the likelihood of an elevated non-specific immune response in fish (Gharaei *et al*. 2020). These results disagreed with the results of the previous study conducted by Diler *et al*. (2021a), which demonstrated that supplementing sumac fruit powder at various levels to the diet had no significant impact on the serum TP and ALB in rainbow trout (O. *mykiss*). In contrast, the use *Laurus nobilis* and *Origanum vulgare* enhanced the non-specific immune parameters in rainbow trout (Bilen and Bulut, 2010; Haghighi and Rohani, 2015).

5. CONCLUSION

Many ongoing studies are focused on examining the effectiveness of incorporating herbal supplements into fish feed to manage diseases and promote the production of fish in a healthy way. The findings of the present study indicate that dietary supplementation sumac (SFP 0.3%, SFP 0.6%, SFP 0.9%) in *C. carpio* significantly enhances their immunological responses, hematological parameters and growth performance. On the other hand, improvement of these parameters with SFP supplementation can reduce stress and enhance immunity in cultured fish. These results are of particular significance due to the limited understanding of the beneficial functional properties of sumac in *C. carpio*. Therefore, further research is required to elucidate the underlying protective mechanisms of sumac extracts in this species.

REFERENCES

Abbasi Ghadikolaei, H., Kamali, A., Soltani, M., & Sharifian, M. (2017). Effects of Zingiber officinale powder on growth parameters, survival rate and biochemical composition of body in juvenile common carp (Cyprinus carpio).

Abu-Reida, I. M., Jamous, R. M., & Ali-Shtayeh, M. S. (2014). Phytochemistry, pharmacological properties and industrial applications of Rhus coriaria L.(sumac). *Jordan journal of biological sciences*, *147*(1573), 1-12.

Ahmadifar, E., M. Yousefi, M. Karimi, R. F. Raieni, M. Dadar, S. Yilmaz, M. A. O. Dawood, and H. M. R. Abdel-Latif. (2021). Benefits of dietary polyphenols and polyphenol-rich additives to aquatic animal health: An overview. Reviews in Fisheries Science & Aquaculture. doi:10.1080/ 23308249.2020.1818689.

Akrami, R., Gharaei, A., Mansour, M. R., & Galeshi, A. (2015). Effects of dietary onion (Allium cepa) powder on growth, innate immune response and hemato–biochemical parameters of beluga (Huso huso Linnaeus, 1754) juvenile. *Fish & shellfish immunology*, *45*(2), 828-834.

Aliakbarlu, J., Mohammadi, S., & Khalili, S. (2014). A study on antioxidant potency and antibacterial activity of water extracts of some spices widely consumed in I ranian diet. *Journal of Food Biochemistry*, *38*(2), 159-166.

Aragona, M., Lauriano, E. R., Pergolizzi, S., & Faggio, C. J. N. P. R. (2018). Opuntia ficus-indica (L.) Miller as a source of bioactivity compounds for health and nutrition. *Natural product research*, *32*(17), 2037-2049.

Barton, B. A. (2002). Stress in fishes: A diversity of responses with particular reference to changes in circulating corticosteroids. Integrative and Comparative Biology 42 (3):517–25. doi:10.1093/icb/42.3.517

Bilen, S., & Bulut, M. (2010). Effects of laurel (Laurus nobilis) on the non-specific immune responses of rainbow trout (Oncorhynchus mykiss, Walbaum). Journal of Animal and Veterinary Advances, 9(8), 1275-1279.

Boyd, C. E., & C. S. Tucker. 2012. Pond aquaculture water quality management. Boston, MA: Kluwer Academic Publishers.

Burgos-Aceves, M. A., Cohen, A., Smith, Y., & Faggio, C. (2018). MicroRNAs and their role on fish oxidative stress during xenobiotic environmental exposures. *Ecotoxicology and Environmental safety*, *148*, 995-1000.

Cakmak, M., Ozcan, N., & Denli, M. (2017). Effects of sumac powder (Rhus coriaria l.) on growth performance, serum biochemistry and intestinal microbioata in broilers at different stocking densities Scientific Papers: Series D. *Animal Science. In: The International session of scientific communications of the faculty of animal science*, *60*.

Carbone, D., & Faggio, C. (2016). Importance of prebiotics in aquaculture as immunostimulants. Effects on immune system of Sparus aurata and Dicentrarchus labrax. *Fish & Shellfish Immunology*, *54*, 172-178.

Choudhury, D., & Nimbalkar, S. (2005). Seismic passive resistance by pseudo-dynamic method. *Geotechnique*, *55*(9), 699-702.

Diler, Ö., Özil, Ö., Bayrak, H., Yiğit, N. Ö., Özmen, Ö., Saygın, M., & Aslankoç, R. (2021a). Effect of dietary supplementation of sumac fruit powder (Rhus coriaria L.) on growth performance, serum biochemistry, intestinal morphology and antioxidant capacity of rainbow trout (*Oncorhynchus mykiss*, Walbaum). *Animal Feed Science and Technology*, *278*, 114993.

Diler, Ö., Öznur, Ö. Z. İ. L., DİLER, İ., DOGUC, D., DİLER, A., & ÇELİK, S. (2021b) Effect of Dietary Sumac (*Rhus coriaria* L.) Supplementation on Non-Specific Immune Response and Hematology of Rainbow Trout (*Oncorhynchus mykiss*), Resistance Against *Vibrio anguillarum*. *Acta Aquatica Turcica*, *17*(1), 88-96.

Dzobo, K. (2022). The role of natural products as sources of therapeutic agents for innovative drug discovery. *Comprehensive Pharmacology*, 408.

Faggio, C., Pagano, M., Alampi, R., Vazzana, I., & Felice, M. R. (2016). Cytotoxicity, haemolymphatic parameters, and oxidative stress following exposure to sub-lethal concentrations of quaternium-15 in Mytilus galloprovincialis. *Aquatic Toxicology*, *180*, 258-265.

FAO (2023). Cyprinus carpio Linnaeus,1758. Fisheries and Aquaculture Division [online]. Rome. [Cited Sunday, June 18th 2023]. https://www.fao.org/fishery/en/ aqspecies/fcp

Fazio, F., Piccione, G., Arfuso, F., & Faggio, C. (2015). Peripheral blood and head kidney haematopoietic tissue response to experimental blood loss in mullet (Mugil cephalus). *Marine Biology Research*, *11*(2), 197-202.

Félix, F., Oliveira, C. C., & Cabrita, E. (2021). Antioxidants in Fish Sperm and the Potential Role of Melatonin. *Antioxidants*, *10*(1), 36.

Gabr, S. A., & Alghadir, A. H. (2019). Evaluation of the biological effects of lyophilized hydrophilic extract of Rhus coriaria on myeloperoxidase (MPO) activity, wound healing, and microbial infections of skin wound tissues. *Evidence-Based Complementary and Alternative Medicine*, *2019*.

Gabriel, N. N. (2019). Review on the progress in the role of herbal extracts in tilapia culture. *Cogent Food & Agriculture*, *5*(1), 1619651.

Gál, D., Kerepeczki, É., Kosáros, T., Hegedűs, R., Pekár, F., & Váradi, L. (2009). Water treatment of intensive aquaculture systems through wetlands and extensive fish ponds–Case studies in Hungary. SustainAqua–"Integrated approach for a sustainable and healthy freshwater aquaculture" SustainAqua handbook–A handbook for sustainable aquaculture, 26-42. https://www.yumpu.com/en/document/view/18501290/a-handbook-for-sustainable-aquaculture-haki

Galina, J., Yin, G., Ardó, L., Jeney, Z. (2009). The use of immunostimulating herbs in fish. An overview of research. Fish Physiol. Biochem. 35, 669–676.

Gharaei, A., Shafie, M., Mirdar Harijani, J., Hasanein, P., & Arshadi, A. (2020). Immune Responses and Haematological Parameters Changes of Rainbow Trout (Oncorhynchus mykiss) under Effects of Dietary Administration of Sumac (Rhus coriaria L.). *Journal of Agricultural Science and Technology*, *22*(1), 173-186.

Ghasemi, R., Faghani, M., Reza, J. P., Khonmirzaiee, N., & Rahimian, Y. (2014). Using sumac (Rhus coriaria L.) extract affect performance and intestinal characteristics of broiler chicks. *Scholarly Journal of Agricultural Science*, *4*(8), 442-445.

Golzadeh, M., Farhoomand, P., & Daneshyar, M. (2012). Dietary Rhus coriaria L. powder reduces the blood cholesterol, VLDL-c and glucose, but increases abdominal fat in broilers. *South African journal of animal science*, *42*(4), 398-405.

Haghighi, M., & Rohani, M.S. (2015). Non-specific immune responses and heamatological parameters of rainbow trout (Oncorhynchus mykiss) fed with Origanum vulgare extract diets. American Advanced Journal Biological Science, 1(1), 1-9.

Hai, N. V. (2015). The use of probiotics in aquaculture. *Journal of applied microbiology*, *119*(4), 917-935.

Hassan, A. A. M., Yacout, M. H., Khalel, M. S., Hafsa, S. H. A., Ibrahim, M. A. R., Mocuta, D. N., ... & Dediu, L. (2018). Effects of some herbal plant supplements on growth performance and the immune response in Nile tilapia (Oreochromis niloticus). *Sciendo*, *1*, 134-141.

Hoseinifar, S. H., Yousefi, S., Capillo, G., Paknejad, H., Khalili, M., Tabarraei, A., & Faggio, C. (2018). Mucosal immune parameters, immune and antioxidant defence related genes expression and growth performance of zebrafish (Danio rerio) fed on Gracilaria gracilis powder. *Fish & shellfish immunology*, *83*, 232-237.

Karnai, L., & Szűcs, I. (2018). Outlooks and perspectives of the common carp production. *Roczniki (Annals)*, *2018*(1230-2019-3607).

Kheiri, F., Rahimian, Y., & Nasr, J. (2015). Application of sumac and dried whey in female<? xmltex\newline?> broiler feed. *Archives Animal Breeding*, *58*(1), 205-210.

Kosar, M., Bozan, B., Temelli, F., & Baser, K. H. C. (2007). Antioxidant activity and phenolic composition of sumac (Rhus coriaria L.) extracts. *Food chemistry*, *103*(3), 952-959.

Kossah, R., Nsabimana, C., Zhao, J., Chen, H., Tian, F., Zhang, H., & Chen, W. (2009). Comparative study on the chemical composition of Syrian sumac (Rhus coriaria L.) and Chinese sumac (Rhus typhina L.) fruits. *Pakistan Journal of Nutrition*, *8*(10), 1570-1574.

Mahdavi, S., Hesami, B., & Sharafi, Y. (2018). Antimicrobial and antioxidant activities of Iranian sumac (Rhus coriaria L.) fruit ethanolic extract. *J. Appl. Microbiol. Biochem*, *2*(5), 2576-1412.

Mansoub, N. H. (2011). Effect of different levels of Sumac Powder (Rhus coriaria L.) on performance, carcass and blood parameters of broiler chickens. *Annals of Biological Research*, *2*(5), 647-652.

Mavlyanov, S. M., Islambekov, S. Y., Karimdzhanov, A. K., & Ismaikov, A. I. (1997). Anthocyans and organic acids of the fruits of some species of sumac. *Chemistry of Natural Compounds*, *33*(2), 209-209.

Najjar, F., Rizk, F., Carnac, G., Nassar, R., Jabak, S., Sobolev, A. P., ... & Hamade, A. (2017). Protective effect of Rhus coriaria fruit extracts against hydrogen peroxide-induced oxidative stress in muscle progenitors and zebrafish embryos. *PeerJ*, *5*, e4144.

Nasar-Abbas, S. M., & Halkman, A. K. (2004). Antimicrobial effect of water extract of sumac (Rhus coriaria L.) on the growth of some food borne bacteria including pathogens. *International journal of food microbiology*, *97*(1), 63-69.

Nath, S., Matozzo, V., Bhandari, D., & Faggio, C. (2019). Growth and liver histology of Channa punctatus exposed to a common biofertilizer. *Natural product research*, *33*(11), 1591-1598.

Onkar, S., Mohammed, A., Nida, A., & Ali, M. (2011). New antifungal aromatic compounds from the seeds of Rhus coriaria L. *International Research Journal of Pharmacy*, *2*(1), 188-194.

Ozkan, G., Baydar, H., & Erbas, S. (2010). The influence of harvest time on essential oil composition, phenolic constituents and antioxidant properties of Turkish oregano (Origanum onites L.). *Journal of the Science of Food and Agriculture*, *90*(2), 205-209.

Panico, A., Cardile, V., Santagati, N. A., & Messina, R. (2009). Antioxidant and protective effects of sumac leaves on chondrocytes. *Journal of Medicinal Plants Research*, *3*(11), 855-861.

Pham-Huy, L. A., He, H., & Pham-Huy, C. (2008). Free radicals, antioxidants in disease and health. International journal of biomedical science: IJBS, 4(2), 89.

Sağlam, M., Köseoğlu, S., Hatipoğlu, M., Esen, H. H., & Köksal, E. (2015). Effect of sumac extract on serum oxidative status, RANKL/OPG system and alveolar bone loss in experimental periodontitis in rats. *Journal of Applied Oral Science*, *23*, 33-41.

Seibel H, Baßmann B and Rebl A (2021) Blood Will Tell: What Hematological Analyses Can Reveal About Fish Welfare. Front. Vet. Sci. 8:616955. doi: 10.3389/fvets.2021.616955

Shafiei, M. (2017). *Effect of dietary Sumac (Rhus coriaria) on survival, growth parameters and gene experession of IL-10, IL-1β, TNF-α of Rainbow trout (Oncorhynchus mykiss)* (Doctoral dissertation, University of Zabol).

Shahbaz, S. E., Saleem, J. I., & Abdulrahman, S. S. (2015). Rhus coriaria var. zebaria (Anacaridaceae), a new variety from Iraq. *Nordic journal of botany*, *33*(1), 50-56.

Thanikachalam, K., Kasi, M., & Rathinam, X. (2010). Effect of garlic peel on growth, hematological parameters and disease resistance against Aeromonas hydrophila in African catfish Clarias gariepinus (Bloch) fingerlings. *Asian Pacific Journal of Tropical Medicine*, *3*(8), 614-618.

Toghyani, M., & Faghan, N. (2017). Effect of sumac (Rhus coriaria L.) fruit powder as an antibiotic growth promoter substitution on growth performance, immune responses and serum lipid profile of broiler chicks. *Indian Journal of Pharmaceutical Education and Research*, *51*(3), 295-298.

Valiollahi, M. R., Gholami, M., Namjoo, A. R., Rahimian, Y., & Rafiee, A. (2014). Effect of using sumac (Rhus coriaria L.) and ajwain (Trachyspermum copticum) powders on performance and intestinal microbial population in broiler chicks. *Research Opinions in Animal and Veterinary Sciences*, *4*(10), 545-549.

Van Doan, H., Hoseinifar, S. H., Faggio, C., Chitmanat, C., Mai, N. T., Jaturasitha, S., & Ringø, E. (2018). Effects of corncob derived xylooligosaccharide on innate immune response, disease resistance, and growth performance in Nile tilapia (Oreochromis niloticus) fingerlings. *Aquaculture*, *495*, 786-793.

Yousefi, M., Hoseini, S. M., Vatnikov, Y. A., Kulikov, E. V., & Drukovsky, S. G. (2019). Rosemary leaf powder improved growth performance, immune and antioxidant parameters, and crowding stress responses in common carp (Cyprinus carpio) fingerlings. *Aquaculture*, *505*, 473-480.

الخلاصة

هدفت هذه التجربة إلى دراسة تأثير المكمل الغذائي لصنف جديد من بودرة فاكهة السماق (*Rhus coriaria var. zebaria*) بتركيزات مختلفة على أداء النمو والكيمياء الحيوية في الدم وصورة الدم لفصيلة الكارب الشائع (*Cyprinus carpio* L.). تم .زرع 128 صغار سمكة بوزن ابتدائي (40 ± 4 جم) عشوائيا في 16 خزان (70 لتر) بكثافة 8 أسماك لكل حوض. عولجت الأسماك في 12 خزاناً بأعلاف تجريبية بثلاث تركيزات مختلفة (3 ، 6 ، 9 جم / كجم) لمدة 10 أسابيع. أدت إضافة 3 جم كجم من مسحوق ثمار السماق إلى النظام الغذائي بشكل ملحوظ (P <0.05) إلى تحسين معظم سمات النمو المدروسة مثل زيادة الوزن (WG ، g)، كفاءة التحويل الغذائي (FCE)، نسبة كفاءة البروتين (PER)، معدل النمو المحدد (SGR٪) و وزن السمك النهائي (FBW، g) مقارنة بالمجموعة الأخرى، ولكن أقل قيمة لهذه الصفات سجلت في المجموعة الكونترول. الزيادات الكبيرة (P <0.05) في خلايا الدم البيضاء(WBC (× 10^{9} / L) ، الخلايا الليمفاوية (LYM × 10^{9} / L)، (MON × 10^{9} / L) لوحظت في مجموعة 0.3 SFP. وإدراج 6 جم / كجم من السماق، أدى بشكل ملحوظ (P <0.05) إلى زيادة عدد كرات الدم الحمراء (× 10^{12} / لتر) ، والهيموجلوبين (HGB، g / L)، فى المحموعات الأسماك المعروض لنظام الغذائي 3 جم و 6 جم/ كجم من بودره السماق، أدى إلى انخفاض معنوي (P <0.05) في الجلوكوز والكوليسترول الكلي (CHO) والدهون الثلاثية (TG) وكوليسترول البروتين الدهني منخفض الكثافة (LDL).

پوختە

مەرەم ژ ئەنجامدانا ڤێ ڤەکۆلینێ خواندن و دیارکرنا کارتێکرنا سماقا هویرکرییە ژ جورێ (*Rhus coriaria var. zebaria*) ل سەر ماسییا کارب (*Cyprinus carpio* L.) دەمێ وەك پارڤەکەر و تەمامکەرێ خورانێ دهێتە بکارئینان ب برێن جودا. 128 ماسییێن بچویك ب کێشەیا (40 ± 4 گرام) هاتنە خودانکرن د ناڤ 16 حەوزێن پلاستیکی دا یێن قەبارێ وان (70 لیتر) ب چرییا (8 ماسی بۆ هەر حەوزەکێ). 12 گروپ ژ ڤان ماسییان هاتنە سەرەدەریکرن ب وان ئالیکێن ڕێژەییێن جودا جودا ژ سماقێ د ناڤ دا (3، 6، 9 گرام / کگم) و هاتنە هەڤبەر کرن د گەل هەر چوار گرۆپێن دی یێن ماسییا ئەوێن خوارنا وان ڤالا ژ پارڤەکەرێن سماقێ. بکارئینانا 3 گم/ گم یێن هویرکێ سماقێ د ناڤ ئالیکێ ماسییا دا بۆ ئەگەرێ باشترکرنا پتریا وان تایبەتمەندییێن هاتینە خواندن یێن گرێدای ب گەشەیا ماسییا ڤە وەکی کێشا ماسییا (گرام) ب ئەدایا گوهۆڕینا خوارنێ (FCE) ئاستێ ڕێژا ئەدایا پرۆتینی (PER) و تێکرایا گەشەیا دەستنیشانکری (SGR٪) و کێشا ماسییا یا دووماهیکێ دئاستێ (P <0.05) دا ل دەمێ هاتینە هەڤبەرکرن د گەل گرۆپێ ماسییا یێ کونترۆلی و نزمترین بها ژی ب وان تایبەتمەندییێن ل سەری هاتینە بەحسکرن د ناڤ گرۆپێ کونترۆلی دا هاتنە خویاکرن. هەروەسا خرۆکێن سپی یێن خوینێ (WBC (× 10^{9} / L) (LYM × 10^{9} / L)، (MON × 10^{9} / L) خروکێن سۆر یێن خوینێ بەرزبوونەکا بەچاڤ بخۆڤە دیت (P <0.05) د گروپێ سماق هاتییە بکارئینان ب ڕێژەیا (SFP 0.3%). دیسان پارڤەکرنا سماقا هویرکری (ب قەبارێ (SFP 0.6%) د ناڤ ئالیکێ ماسییا دا بۆ ئەگەرێ باشترکرنا ئاستێ گەلەگ ژ تایبەتمەندییێن دی یێن خوینێ وەکی خرۆکێن سۆر یێن خوینێ (10^{12} / لیتر، RBC)، هیموگلۆبین (g / L، HGB)، د ئاستێ (P <0.05) دا. هەروەسان د هەردوو کومەلێن ماسییا یێن هاتینە سەرەدەریکرن ب ئاستێن 3 گرا/کگم و 6 گم/ کگم یێن سماقا هویرکری د ناڤ ئالیکی دا بوویە ئەگەرێ کێمکرمەکا باش و بەرچاڤ (P <0.05) د گلۆکوزی و کولیسترولێ گشتی (CHO) و روینێ سیانی (TG) و کولیسترولێ پرۆتینی یێ چری کێم (LDL).