



Valorization of Olive Mill Wastewater in COBB 500 Chicken Feed: Impacts on Carcass Characteristics and Meat Quality

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Volume 7, Issue 2, Feb 2025

Received: 05 Jan 2025

Accepted: 29 Jan 2025

Published: 09 Feb 2025

[doi:10.48047/AFJBS.7.2.2025.427-446](https://doi.org/10.48047/AFJBS.7.2.2025.427-446)

Abstract:

The aim of this research was to evaluate the effect of incorporating olive wastewater (OWW) into the diet of Cobb 500 broiler chickens on zootechnical performance, carcass characteristics as well as to study meat physicochemical properties indicators of technological quality. The experiment involved a total of 100 broiler chicken aged 45 days. The rate of total phenols, tannins, sugars, dry matter and minerals ($P < 0.001$) in the diet of the two standard formulas and with olive wastewater showed a significant variation. At slaughter, meat physicochemical characteristics were measured on pectoral muscle. A significant difference was observed in body weight gain ($P < 0.001$), feed conversion ratio ($P < 0.001$) and mortality rate ($P < 0.03$) with improvement in the condition of the batch subjects receiving a diet with OWW. Statistically, the carcass yield differed significantly between the two groups, notably in breast and thigh weights ($P < 0.001$). Technological properties, such as myoglobin content ($P < 0.0$, Napole yield, and meat texture ($P < 0.001$) were also enhanced, reflecting better color, tenderness, and cutting yield. This study is the first to analyse and compare the physicochemical proprieties of cobb 500 strain broiler meat in Algeria after incorporation of olive wastewater

Key words: olive wastewater, diet, broiler, meat, quality

Introduction:

In Algeria, the growing demand for animal proteins is constrained by their high cost, which limits their consumption. The poultry sector, as the most developed in the country, offers a promising solution to address nutritional needs. However, the rising prices of key raw materials, such as maize, soybean, and oilseed cakes, pose a significant challenge to the sector's growth (FAO, 2020). In this context, exploring sustainable and cost-effective dietary alternatives is essential to optimizing the performance of the poultry industry while reducing production costs.

Olive mill wastewater (OMWW), a liquid by-product of olive oil production, offers a promising alternative source. OMWW is characterized by a high content of organic and mineral compounds (proteins, phenols, tannins, sugars, etc.) and an acidic pH. However, these residues pose serious environmental challenges due to their high organic load and polluting potential (**Hassen *and al.*, 2023; Foti *and al.*, 2021**). When untreated, OMWW negatively affects aquatic ecosystems, soils, and air quality, especially in the Mediterranean region, where olive oil production is concentrated (**Khdaïr and Abu-Rumman., 2017; Dermeche *and al.*, 2013**).

Despite these challenges, OMWW holds promising valorization potential. It can be used as a fertilizer in agriculture, as a source of bioactive molecules for industrial applications, or can be incorporated into animal feed to enrich diets and reduce costs (**Ahmad *and al.*, 2020**).

This study investigates the incorporation of OMWW into broiler chicken diets and examines its effects on growth performance, slaughter yield, and meat quality. The methodology includes a nutritional analysis of feed rations and a thorough assessment of meat quality parameters.

Materials and methods:**Animal and diets:**

The experiment was conducted on 3000 broiler chicks of the COBB 500 strain, which were immunized and primed-vaccinated. The chicks, sourced from SARL Nutri Aliment Plus (NAP), divided into two groups of 1500 each. One group was fed a standard diet, while the other received an experimental formula incorporating olive wastewater (OWW) from a three-phase extraction system. The OWW stored at 4°C in a dark oxygen-free environment. Both diets were identical except for the replacement of water with raw olive wastewater in the experimental feed, which was provided as crumbs during the starter phase and then as pellets during the grower and finisher phases. The feed was distributed twice daily, with a gradual transition between the starter and grower phases. At 45 days, the animals were slaughtered, and their samples were stored in cold rooms to allow maturation and prevent microbial growth. The technological quality of the meat was analyzed using 100 pectoral muscle samples, 50 from each batch, including the evaluation of chemical parameters of both fresh and matured meat.

Chemical characterization of feed:

The characterization of the standard diet and the new formulation incorporating olive oil liquid effluent as a water substitute focused on determining the dry matter content, calculated by subtracting the water content from 100%. Protein content was measured using the Kjeldahl method (**ISO 5983-1, 2005**), while fat content was analyzed with the Soxhlet method. Ash content was determined by incinerating the samples, and carbohydrate content was measured using the Dubois method. (**Dubois and al., 1956**)

Since decoction provides good extraction yields, and maceration is effective for polyphenol extraction (**Mahmoudi and al., 2013**), both techniques were utilized. Two grams of powdered food were mixed with 40 ml of extraction solvent (ethanol, acetone, methanol, and water), left to macerate for one hour, and then heated in a water bath for 30 minutes. The mixture was filtered through muslin cloth to recover the filtrate and then centrifuged at 4000 rpm for 20 minutes. The samples were stored in Eppendorf tubes at 4°C until analysis. The total phenol content was quantified using the Folin Ciachoulo method. Total tannins were determined using the method of (**Makkar and al., 1993**) and (**Koutouan and al., 2019**), a colorimetric technique based on the bonding of tannins with PVPP (polyvinylpyrrolidone) which is an insoluble polymer. Condensed tannins were quantified using the butanol-HCl technique, recognized as the most sensitive and reproducible method for measuring condensed tannins, according to (**Ben Moussa and al., 2022**). The level of flavonoids was determined using the colorimetric method of aluminum trichloride described by (**Essam and al., 2012**).

Growth performance:

A regular, weekly monitoring of zoo technical parameters was conducted including growth performance indicators, such as mortality rate, feed conversion ratio, weight gain, and feed conversion ratio. These technical criteria were measured throughout the rearing process.

Slaughter yield:

After sanitizing the chickens, a series of operations on the slaughter line enabled the calculation of eviscerated carcass yield and abdominal fat as a percentage of live body weight. Noble organs, including breast and thigh, along with offal like the liver, were estimated as a percentage of the carcass weight.

Meat quality proprieties:

pH measurement: The pH measurement was performed using a pH meter with the electrode inserted into a beaker containing meat and a pH buffer. The buffer consisted of 150 mM potassium chloride and 5 mM sodium iodoacetate, which inhibits postmortem glycolysis, following the protocol by (**Mc Green and al., 2000**).

Water holding capacity (WHC): Water holding capacity was studied using the centrifugation technique as outlined by (Zhang *and al.*, 2012). WHC was expressed in grams of juice per gram of meat and was calculated using the following formula: $WHC = \frac{\text{weight of juice}}{\text{weight of sample meat}} \times 100$

Cooking Loss: Cooking loss was determined by measuring the ratio of meat mass before and after cooking, following the method of (Paul and Pascual, 2007). A 5 g sample of meat, sealed in an impermeable cooking bag, was immersed in a water bath at 80°C for one hour. Cooking loss (CL) was calculated using the formula: $CL = \frac{\text{weight before boiling} - \text{weight after boiling}}{\text{weight before boiling}} \times 100$

Myofibril fragmentation index: The myofibril fragmentation index was calculated using the method of (Li *and al.*, 2012). Protein concentration was measured using the Bradford technique and diluting to achieve a concentration of 0.5 ± 0.05 mg/ml. The MFI value was calculated by multiplying the absorbance of the myofibrillar suspension at 540nm by 200.

Myoglobin concentration: The colorimetric assay of myoglobin, following (Canto *and al.*, 2015) approach, involved homogenizing 2 g of meat with 15 ml of phosphate buffer, adjusted to pH 6, 8. The homogenate was filtered in the dark using Wattman paper to limit myoglobin oxidation. The filtrate's optical density was measured at 525 nm using a UV spectrophotometer. The myoglobin concentration was calculated using the formula below: $[\text{Myoglobin}] \text{ (mg/g)} = \frac{A}{(7.6 \text{ mM}^{-1} \text{ cm}^{-1} \times 1 \text{ cm})} \times [17000/1000] \times 10$

Napole yield: Analyzing the weight loss of meat after marinating and cooking is a reliable technique essential for evaluating meat processing and quality. The method suggested by (Molette, 2004) involves removing the fat and connective tissue from the pectoral muscle, taking 104 grams (P1) of mature meat in 1 cm³ cubes, and submerging it in a brine prepared with 136 grams of nitrite salt and one liter of distilled water. After overnight marination, the samples were cooked for fifteen minutes in a bain-marie with boiling water. The cooked samples were drained for two hours and thirty minutes, then weighed (P2). The

technological yield is provided by the formula: $RTN = \frac{P_2}{P_1} \times 100$

Texture measurement: An indirect method was used to estimate meat texture by applying compression forces. This approach enabled our team to calculate pressure. Images of the meat cubes were captured before and after compression and were analyzed with Image J software. The pressure is calculated using the formula: $(P=F/A)$

Statistical analysis: Three measurements were taken for each parameter under analysis, and the results are expressed as the mean \pm standard deviation. Differences between the animal groups were assessed using a one-way analysis of variance (ANOVA) at the 5% significance level. Data analysis was performed with XLSTAT 2023. The Shapiro-Wilk test was applied to assess the homogeneity of variance and normality between the two bird groups. Pearson correlation analysis was conducted to investigate potential relationships between the ingredients in the new food formula with olive wastewater and meat quality attributes. Finally, the principal components analysis (PCA) was used to describe the discrimination of the groups with all differences and correlations.

Biochemical characterization of feed:

The biochemical makeup of the two diets used in the experiment is shown in table 1. Significant differences ($p \geq 0.001$) were observed between the two feed rations in parameters such as dry matter, mineral content, sugars, total phenols, and total tannins.

The percentage of DM in the ration with OMWW is higher than that of the standard feed. There was a statistically significant difference ($p < 0.0001$). Our findings are consistent with those of (**Branciarì *and al.*, 2016**), who found that the OMWW in the chicken feed were 91.35% while the control diet was 89.9%.

The difference between the two rations was remarkably significant ($P = 0.000$). These findings are consistent with previous research conducted by (**Branciarì *and al.*, 2017**) and (**Herrero-Encinas *and al.*, 2019**), which found higher values (6.14% to 6.37%) and 6.40%), respectively when adding olive cake extract. Furthermore, according to (**Branciarì *et al.*, 2017**), the ash content obtained is close to that of the control feed, which is 5.61%.

The ration enriched with OMWW contains more fat than the standard food. These values are higher than those found by (**Brah *and al.*, 2019**) (3.65-5%) and by (**Herrero-Encinas *and al.*, 2019**) after adding olive pomace extract (5.5%), while this fat fraction is lower than what the previous study found in their control feed (8%). The lipid content of the new formula was impacted by the conclusion that OMWW has a higher lipid content than pomace.

The mean of CP in the new formula with OMWW was lower than the standard diet, but the current study did not find any statistical effects between the two rations. This can be explained by the proteins' bonding with the experimental feed's tannins. Only specific concentrations of margins were approved for inclusion in scientific experiments (**Branciarì *and al.*, 2016**).

The average sugar rate in the diet with olive margins was 8%, compared to 1% in the control formula, according to the estimation of the sugar rates in the two feed formulas, standard and with margins. There was a statistically significant difference ($p = 0.000$). After incorporating the olivewastewater to the broiler feed, our experimental batch's results were better than those allowed by (Herrero-Encinas *et al.*, 2019). The quantity of olive margins added explains this.

Both feeds' phenolic composition was displayed as an average percentage; the new diet with vegetable waters had higher levels of total phenols, hydrolysable and condensed tannins, and flavonoids than the standard feed. This supports the research of (Branciari *and al.*, 2017), who calculated that the control feed had 0.4% polyphenol content, compared to 1.4% and 2.4% in the two diets following low and high amounts of olive pomace supplementation, respectively. Total phenols and total tannins differed significantly, according to the statistical analysis. Due to the anti-nutritional effect of tannins (Hervé *and al.*, 2015).Brah et al. (2019) reported that the feed ration of broiler chickens contained 0.15% tannins. The ability of tannins to precipitate proteins by forming complexes and making them difficult to digest is well known. They also inhibit digestive enzymes like cellulase, lipases, amylase, and proteases, as well as reducing the consumption of minerals and vitamins. Additionally, they have a detrimental effect on the digestibility of amino acids, starches, and lipids, as stated by a number of authors, the concentration of tannins essentially restricts their anti-nutritional properties because low concentrations enhance performance, increase food intake, and prevent bacterial infections because of their inherent antibiotic specificity. They also regulate intestinal flora and transit. (Mohammed Hassen *and al.*, 2020)

Table 01: Biochemical composition of the two standard food rations and those with OMWW

Parameter	DS	DOWW	Signification
Dry matter (%)	89,522±0,023	90,421±0,058	S***
Mineral matter (%)	5,878±0,061	5,331±0,039	S***
Fat (%)	5,100±0,060	6,311±2,285	Ns
CrudeProtein	21,56±1,990	20,44±3,730	Ns
Sugar (%)	1,92±0,57	8,03±0,61	S***
Total phenol (%)	1,712±0,063	8,770±0,00	S***
Flavonoïds (%)	6,795±0,818	15,052±10,919	Ns
Total tannin (%)	6,281±2,563	7,400±0,0516	S***
Condensed tannin (%)	0,078±0,0551	0,0885±0,024	Ns

DS :standard dietary; DOWW : dietary with olive waste water ; Ns: not significant ; * p -value $\leq 0,05$, *** p -value $\leq 0,001$

Growth performance

The zoo technical parameters of the chickens, recorded forty-five days before slaughter are reported in **Table 2**. In both groups that consumed the two diets, the mortality rate, feed conversion ratio, and weight gain were statistically comparable. These findings align with a study by (Branciairi *and al.*, 2016) which reported no significant impact of phenolic compounds isolated from olive wastewater on the growth performance of chickens.

The birds in the experimental group had live weights of 2730 g at 45 days, which is higher than the values reported by (Balzan *and al.*, 2021) at 48 days but lower than those observed by (Branciair *and al.*, 2017) at 42 days. The latter study suggested that adding olive cake to broiler feed may result in lower weights. Though lower than the values discovered by (Branciairi *and al.*, 2017) and (Balzan *and al.*, 2021), the feed conversion ratio appears to be comparable for both groups. Several studies have examined the effects of dried olive pulp (Varmaghany *and al.*, 2013) and extra virgin olive oil [Tufarelli *and al.*, 2016], reporting improvements in farming performance. Other researchers, however, argue that the inclusion of olive pomace (Pecjak *et al.*, 2020) or olive leaves (Papadomichelakis *and al.*, 2019) has no discernible impact on rearing performance.

Table 2: zoo technical criteria from the two batches

Parameter	SG	GOWW	Signification
Feed ingested (Kg)	70000	73000	***
FC	1,75	1,78	***
BWG (g)	2660	2730	***
MR (%)	4,73	1,47	*
DAG	59,11	60,66	***

SG: control group with standard diet, GOWW: experimental group with dietary with OWW; FC: feed conversion ration; BWG: body weight gain at 45 days, MR: mortality .rate; DAG: daily average gain

* $p\text{-value} \leq 0,05$; ** $p\text{-value} \leq 0,001$; *** $p\text{-value} \leq 0,0001$

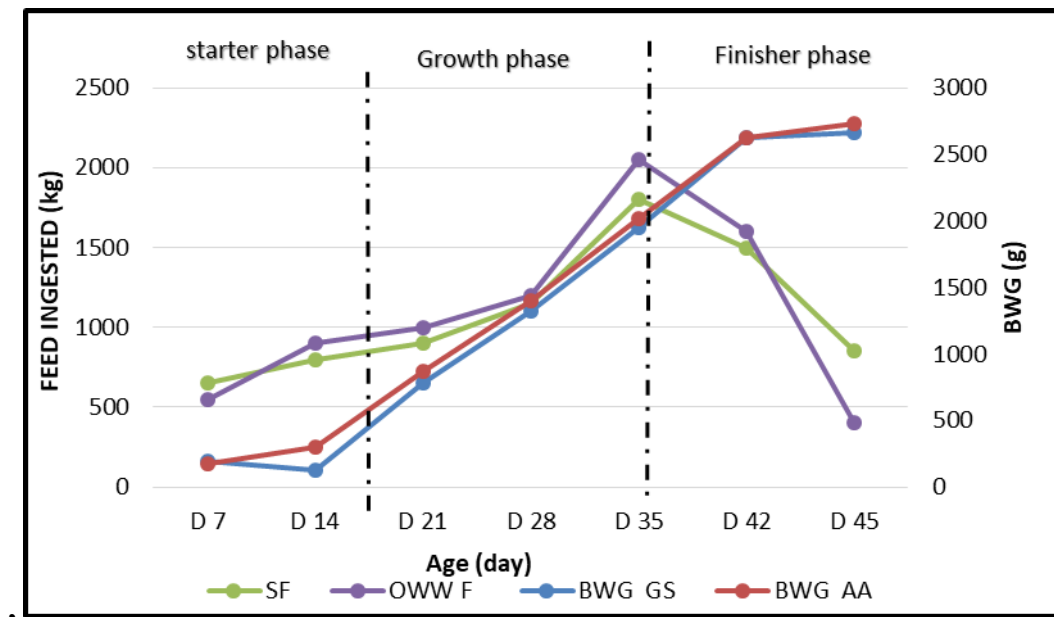


Figure 1: quantity of diet ingested by broiler's and body weight gain weekly during 45 days

SF :stand feed ; OWWF:OWW feed, BWG: body weight gain , GS: standard group; AA:group with OWW feed

Figure 1 shows a two-axis curve showing the amount of feed ingested (Kg), and the weekly weight gain (g) during the three rearing phases for 45 days, it is revealed that there is a statistical difference, The incorporation of OMWW in the diet of chickens allowed to obtain more yield in live weight of the animal.

Slaughter yield:

According to this study, the improved batch produced more carcasses compared to the standard batch., although the difference was not statistically significant, as explained in table 3. The improved batch has more thighs yield than the standard batch, which is higher than the results of (Alnahhas *and al.*, 2014), who observed a yield of $22.7\% \pm 0.07$. Additionally, the improved batch exhibited greater abdominal fat content, with values higher than Richard's 1984 ($2.75\% \pm 0.48$), which is lower than these results. This discrepancy could be attributed to the use of different strains in the studies. The study also demonstrated a higher breast yield in the improved batch compared to the standard batch, which was statistically significant (P-value 5), with a yield range of 21.2 to 25.0%. These results are higher than those of (Gangbedji *and al.*, 2023). This discrepancy may be the result of different animal strains (Ross vs. Cobb500). In comparison to the improved batch, the standard batch has a higher liver yield. The "Performance and Nutritional Recommendations" guide for the "Cobb500" broiler chicken mentions 1.63, which is lower than these results.

The study revealed that the yield of thighs and breast was significantly affected by the inclusion of olive waste water ($p \geq 0,05$). These findings contrast with those of [Branciani *and al.*, 2016], who reported that

chickens fed phenolic compounds extracted from olive wastewater exhibited higher live and carcass weights. Conversely, (Balzan *and al.*, 2021) found no effect of dietary OWW on slaughter yield.

Table 03: effect of diet with olive wastewater on slaughter yield and carcass characteristics:

Variable	GOWW	G S	Significance
LvW	2.271	2.508	Ns
Thigh	32.854	30.033	*
Carcass	84.524	81.064	Ns
Skin fat	3.986	3.239	Ns
Offals	5.275	5.447	Ns
Breast	34.562	31.444	**

GS : standard group; DOWW : group with olive waste water ;Ns: not significant ; * p -value $\leq 0,05$, ** p -value $\leq 0,01$; LvW: liver weight;

Meat proprieties:

The final quality and processing characteristics of the meat were largely determined by the pH of the pectoralis major muscle (Alnahhas *and al.*, 2014). Comparing the two meat samples statistically revealed that the OWW diet had no effect on pH, water retention capacity, cooking loss, or MFI ($p \geq 0,05$). These findings align with the findings by (Branciari *and al.*, 2017) and (Balzan *and al.*, 2021) who found that the addition of olive pomace polyphenols impacted these parameters. According to (Keeton and Osburn., 2010), the post mortem pH of poultry muscle after 24 hours ranges between 6.0 and 6.2.

The compositional differences between the two diets significantly impact the Napole technological yield, compression force (indicative of texture), and color measurement using the myoglobin colorimetric assay. This statistically significant effect ($p \leq 0,001$) is detailed in table 5, which shows the distribution of Napole technological output. The Napole technological yield values for both batches fall within a reasonable range of the 99.11 ± 0.73 results reported by (El rammouz *and al.*, 2005). Similarly, the compression test results demonstrates that the two batches are comparable to those of (El rammouz *and al.*, 2005). For the standard batch, an average of 0.070 ± 0.025 (N/mm²) was observed, which falls within the interval [0.0058-0.324] (N/mm²), when the compression force is at 20%. The improved batch records an average of 0.060 ± 0.014 (N/mm²). However, these figures differ significantly from the findings of (Campo *and al.*, 2000). This discrepancy can be attributed to breed variations and differences in meat maturity. While the beef samples used in the referenced study were matured for 10 days, the chicken samples in our study underwent much shorter maturation period which are 10 days for beef and much less for chicken;

Table 04: Technological parameters studied of meat from the two batches having consumed the standard food and the new formula with OMWW

Parameter	G SF	GOWWF	significance
pH _u	5,986	6,008	Ns
WHC	0.0284	0.0287	Ns
CL	34.21	33.918	Ns
MFI	60,456	79,460	Ns
Myoglobin	0,011	0,677	***
Nplyield	101,92	97,571	***
Texture	0,070	0,060	***

WHC: water holding capacity; CL: cooking loss; MFI: myofibrilr fragmentation index;

NPL:napole yield; *** p -value \leq 0,01.

Correlation and PCA: Meat's physicochemical parameters show both positive and negative correlations, according to the statistics analysis. According to (Fletcher *and al.*, 1999), muscle pH is associated with a number of quality characteristics, such as tenderness, water-holding capacity, cooking loss, juiciness, and shelf life. The link between meat color, muscle pH, and WHC is well-established (Eunju *and al.*, 2020). The findings indicate that PH and myoglobin continent have a negative correlation ($r=-0.65$). This is consistent with (Solo *and al.*, 2016).It is true that low pH in meat causes protein denaturation, which can result in a paler color and a decreased ability to hold water (Papadomichelakis *and al.*, 2019).

A negative correlation ($r= -0,54$) is found between myoglobin pigment and cooking loss. Cooking induces discoloration, primarily due to the oxidation of myoglobin. According to (Tornberg., 2005) this process mostly takes place between 80 and 85°C, along with the oxidation of heme groups. These biochemical alterations highlight the impact of cooking on meat quality. (Samson *and al.*, 2022, Ahmet okay *and al.*, 2018). According to (Dai *and al.*, 2013), this phenomenon may be related to improved color qualities and reduced sarcoplasmic protein denaturation.

The current study reveals a correlation between Napole technological yield and cooking loss. Salt plays a vital role in processed foods; it improves texture, tenderness, aroma, and palatability. It achieves this by promoting the solubilization of meat proteins and serving as a binder between meat and fat (Li *and al.*, 2023).

The correlation matrix in the current study showed a relationship between the protein content of the food ration and cooking loss in meat ($r=-0,56$). A low protein level in the diet is identified as the cause of the reduced percentage of cooking loss in the pectoral muscle. (**Yalçin and al., 2010**).

The current study demonstrated that protein concentration in the diet with olive mill wastewater had no effect on technological meat traits such as pH ($r=0,350$), WHC ($r=0,121$). These results are consistent with **Khatun and al., (2021)**, who found no effect of dietary proteins on the pH, WHC, and CL of chicken muscle but noted a favourable effect on carcass performance and body weight gain. However, low protein levels in broiler feed were found to influence postmortem pH after 24 hours, as noted by **Yalçin and al., (2010)**, while having no discernible effect on WHC or shear force. Sugars in the diet also affected pH variations ($r=-0,61$), so the low-protein diet was attributed for pH values. The imbalance between excessive energy intake and insufficient protein intake led to increased energy storage in broiler muscles at the time of death. This, in turn, decreased pH levels, suggesting higher muscle glycogen reserves. Based on a different correlation between proteins and the myoglobin content ($r= 0,732$), which is consistent with the findings of **Yalçin and al ., 2010**). When broilers were fed a low-protein diet, their meat was paler than when they were fed a high-protein diet.

The study demonstrates a significant relationship between tenderness and protein dietary indicators, with a correlation ($r=0,830$) for MFI and ($r=0,747$) compression test, respectively. This can be attributed to the impact of low protein diets on myofibril density and protein solubility at 42 days, leading to a higher MFI (**Yalçin and al., 2010**). The results of (**Benahmed and al., 2023**) found that supplementing diets with free amino acids to meet birds' amino acid requirements allows for a 3.0% reduction in protein content in grower and finisher diets without negatively affecting breast meat quality. Additionally, Tannin pH and color were found to have a coefficient of correlation of ($r=0,461$) between the tannins in the diet that are enhanced by pH and myoglobin concentration. This finding is consistent with Busye's report that the quality of meat is affected by both hydrolyzable and condensed tannins, despite of their origins. **Buyse and others (2021)** observed that the presence of chestnut tannins in the broiler diet lowers the pH of the meat of ROSS 308 broiler chickens, resulting in a paler coloration with enhanced red and yellow tones. Similarly, **Qioa and al (2001)** reported similar findings in the pectoral muscle of COBB500 broiler chickens. Tannic acid supplementation was demonstrated to improve coloration, lower pH, and reduce cooking loss of breast meat for the same strain. [**Choi and al., 2022**]. Conversely, (**Liu and al.,2020**) and **Mhfuzy and al (2021)** observed an increase in the pH of the breast of ARBOR ACRE broilers when hydrolyzable tannins were added to the diet. These findings suggest that tannins affect the pH, cooking loss, and meat WHC of chicken, with variations likely due to differences in chicken breeds and the types of tannin molecule used.

The physicochemical properties of meat can be influenced by certain products of the oleicus industry. The inclusion of dried olive pulp influenced some physical properties and color attributes in broiler chicken meat by affecting oxidative stability, as our study demonstrated a relationship between phenolic compounds

and certain technological parameters. According to **Papadomichelakis *and al* (2019)**, broiler chickens fed 80g DOP/kg finisher diet showed lower pH (24 hours pm), increased yellowness, reduced pinkness, and higher cooking loss in the breast meat. Additionally, when pigs were fed DOP, **Lopez-García *and al.* (2017)** observed that the meat was paler and less red. However, feeding broilers olive cake or rabbits olive pomace had no effect on the meat color, cooking loss, or pH (**Dal Bosco *and al.*, 2012**)

Table 5: Pearson correlation coefficients between the physicochemical characteristics of chicken meat and the parameters of the new feed formula with OWW

Variable	MFI	Myo	PH	WHC	CL	Npl	Tex	DM(F)	MM(F)	Prot(F)	fat(F)	Sug(F)	TP(A)	Flav(A)	TT(F)	TC(F)
MFI	1															
MYO		1														
PH		0,681	1													
WHC	0,416			1												
CL		-0,54		0,545	1											
Npl		0,017				1										
Tex	0,355						0,87	1								
DM (F)								1								
MM(F)									1							
Prot(F)	0,830				-0,56	0,104	0,747			1						
fat(F)									0,956		1					
Sug(F)									0,68		0,677	1				
TP(F)		-0,5					-0,25		-0,475		-0,45		1			
Flav(F)														1		
TT(F)		-0,73	0,461												1	
CT(F)		0,612							0,841		0,845					1

Correlation coefficient written in bold are considerably different, WHC: water holding capacity; CL: cooking loss; MFI: myofibril fragmentation index; NPL: napole yield, (F) broiler feed; DM: dry matter; MM: mineral matter, prot: proteins, sug: total sugars TT: total tannins, CT: Condensed tannins, TP: total phenols, Flav: flavonoids

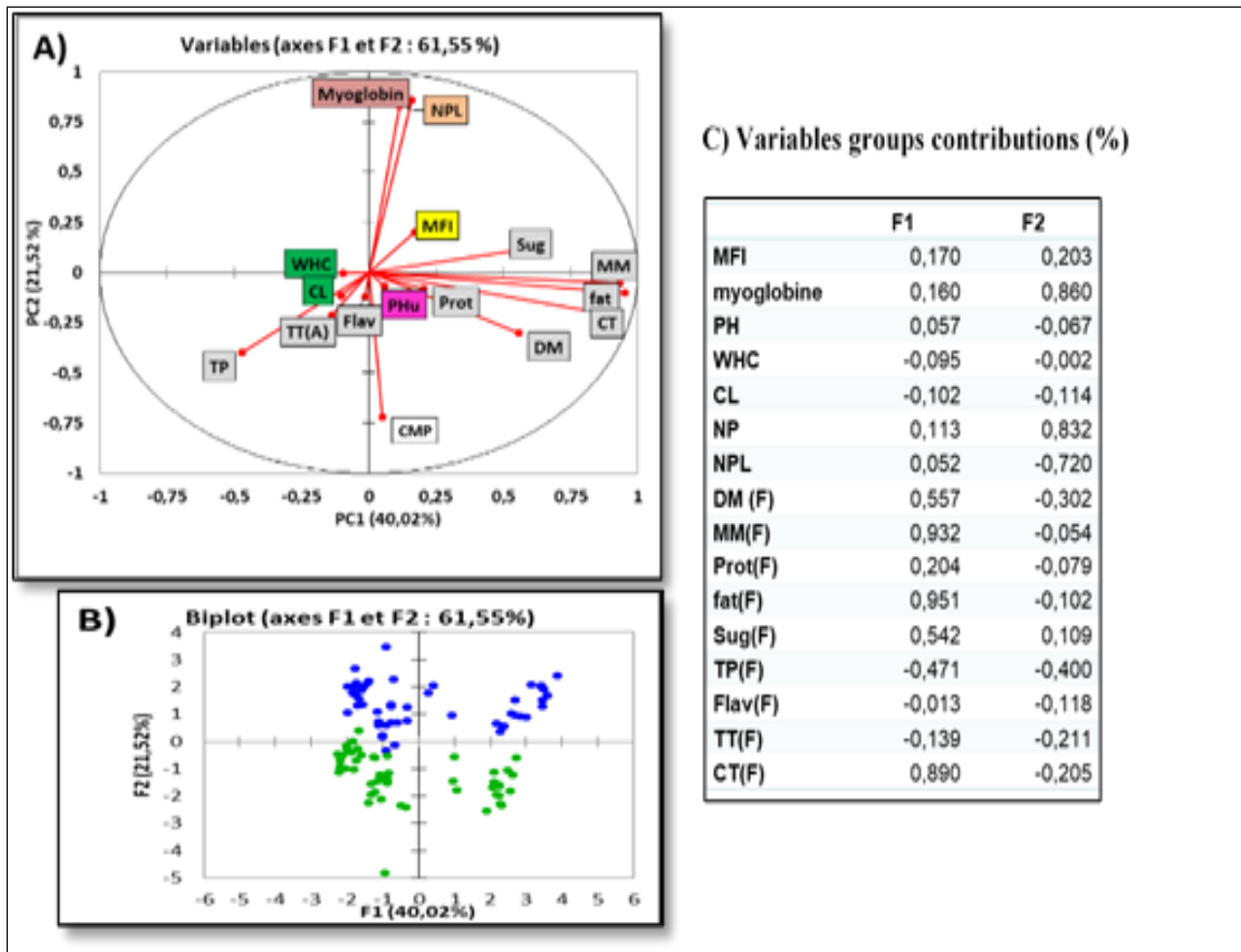


Figure 2.Principal component (PC). **A)** Projection of the studied variables in the two first components. **B)** Bi-plot of the animal groups observations on the two first principal components. **C)** Correlations between PC and variables(%). *pHu*: ultimate pH at 24 p.m; *WHC*: water holding capacity(%);*CL*: cooking losses (%); *MFI*: myofibril fragmentation index;*NPL*: technological yield, *myog*: concentration of myoglobin (%); *Tex*: texture by compression test (%); *DM*: dry matter of diet (%); *MM*: mineral matter of diet(%); *sug*: sugars in diet(%); *TP*: total phenols in diet(%); *TT*: total tannins(%); *CT*: condensed tannins(%); *FLV*: flavonoids in diet (%), (F) food.

Principal component analysis provides a comprehensive illustration of the correlations between the technological parameters of meat: pH, WHC, CL, TEX, Npl, MFI, myoglobin pigment of the pectoral muscle of broilers and the food ration distributed to the animal subjects. The PCA projection applied to the mentioned variables represents (61.55%) of the total variability with two main components (PC1) and (PC2). The first component, presented by the horizontal axis, includes (40.52%) of the total variance. This component includes fat, sugar (sug), condensed tannins (CT), mineral matter (MM), and dry matter (DM) on the positive side, which are positively correlated. On the negative side, total protein (TP) is positioned, indicating an inverse relationship with the positive variables. The vertical axis describes the second component with a percentage of (21.%) of the total variability. This component comprises myoglobin concentration and Napole yield on the positive side, while texture, as measured by compression, occupies the negative side. Generally, variables close to each other on the PCA plot are positively correlated, and

those far from the center turn out to be predominant in the definition of PCA. It seems that the biochemical parameters characterizing the broiler feed contribute to the first component, while the physicochemical parameters indicating the technological quality of the meat are defined by the second component (PC2). The PCA biplot (Figure B) reveals two distinct groups of broilers, distinguished by the biochemical composition of their diets. The two axes make it possible to discriminate between two groups of broilers based on the biochemical composition of feed.

The findings from the statistical analysis further support the distinctions between the two groups under investigation, where meat produced from animals fed different diets (control and OMWW) had varying quality parameters.

Conclusion: The incorporation of olive mill wastewater (OMWW) into broiler chicken feed significantly influenced the composition of the feed, particularly in sugars, mineral matter, total phenols, and condensed tannins, which serve as natural antioxidants. This study demonstrated improvements in zootechnical performance, notably higher yields in thighs and breasts, recognized as premium cuts. The impact on the technological quality of the meat, particularly the preservation of pigmentation and increased shelf life due to polyphenols, was observed. Furthermore, the compression test revealed that meat from animals fed OMWW was more tender than that from the control group. These findings suggest that enriching the feed with olive mill wastewater not only boosts zootechnical performance but also improves meat quality post-processing. Future research could explore the long-term effects of OMWW on animal health and evaluate alternative feed formulations to optimize its advantages while ensuring economic feasibility for the poultry industry.

Acknowledgement: The theme is articulated within the framework of a national research project of the Ministry of Higher Education and Scientific Research in Algeria. The success of this project is the fruit of SARL NAP the unit supplying with the chick and the food to which we address our respectful thanks and gratitude. Our sincere gratitude to the biotechnology research center (CRBT) and the national school of biotechnology (Algeria) for opening their doors to facilitate this research

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