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Research article

Productive and physico-chemical performance at two seasons of the year in trout *(Oncorhynchus mykiss)*

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Abstract

The objective of the research was to evaluate the productive and physicochemical performance of trout *(Oncorhynchus mykiss)* in two seasons of the year. The months of April-June for the rainy season and July-September for the dry season in the Junín region of Peru were considered. The productive performance variables were: length, live weight, carcass weight, and yield; on the other hand, the physicochemical variable (pH, water retention, humidity, ash, ethereal extract, and protein). The results indicate that no differences (P>0.05) were found between the rainy and dry seasons for length (cm), moisture (%), ash (%), ethereal extract (%), and protein (%). On the contrary, differences (P<0.05) were found between the rainy and dry seasons for live weight (g) with 239.37 g and 186.30 g respectively, as well as differences for carcass weight (g) in the rainy (186.30 g) and dry (140.77 g) seasons; likewise, differences were found for carcass yield (%), with 77.68 % and 75.52 % for the rainy and dry seasons, respectively. It is evident that in the rainy season, there is an increase in their productive behavior. In terms of physicochemical performance, both seasons do not influence the chemical characteristics.

Keywords: Arco iris trout, Length in trout, Meat quality, Productive performance

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INTRODUCTION

Globally, trout farming is increasing and is one of the hydrological resources consumed with the greatest potential for aquaculture; to meet the food needs every year the figures are increasing, representing 50% of the total products consumed (FAO, 2016; Zárate et al., 2018). Developing countries are investing their household economies in aquaculture production (Food and Agriculture Organization, 2018b). In Peru, trout farming has been increasing rapidly in recent years, with trout (*Oncorhynchus mykiss*) being the main aquaculture species (Calderón et al., 2022), in Junín there is a significant rainbow trout (*Oncorhynchus mykiss*) fish production farms that is used as economic income, however, the quality of nutrients provided by these animals is unknown (Fuentes and Pérez, 1998; Senderovich et al., 2010).

Food consumption must guarantee food safety (Filser et al., 2019) to preserve human health, as well as to guarantee the quality of the food produced (Sachs, 2012). However, not all producers have access to qualify or evaluate the nutritional or chemical quality of trout carcasses and even more so their bacteriological content (Food and Agriculture Organization, 2018a). It is important to analyze the quantity - microbiological and bacteriological quality to prevent and mitigate risks to consumption (Cabral, 2010).

Physicochemical compositions are important variables in the analysis of trout meat quality, the most important of which is protein (Hart and Fisher, 1991), trout has high-quality proteins (D'Agaro et al., 2013; Maiolo et al., 2021), Trout also has omega-3 and 6, which are highly recommended in all diets to prevent cardiovascular disease and reduce the incidence of cancerous tumors (Corser et al., 1999). The quality and quantity of water are related to the fat and protein content of the meat (García-Macías et al., 2004). The increase in trout production in Peru promotes the need to obtain knowledge of its chemical characteristics for scientific development in this species (Romero et al., 1996; Ustun et al., 1996), chemical components of trout meat are proportional to the physiological state of the fish, as well as the efficiency of the feed, time, and amount of water (Bulancea y Rapeanu, 2009). It is very important that the nutritional value of the product is known for trout carcasses at different times of the year (Mocanu et al., 2012). There are few studies worldwide on the impact of rainy seasons on the productive and physicochemical characteristics of fish meat (Kalinjak, 2019).

Therefore, the purpose was to analyze the productive and physicochemical performance of trout (*Oncorhynchus mykiss*) in two seasons of the year. The following productive performance variables were evaluated: trout length (cm), live weight (g), carcass weight (g) and carcass yield (%). Physicochemical performance: moisture (%), ash (%), ethereal extract (%), protein (%), pH, water holding capacity (%), and acidity.

MATERIALS AND METHODS

The procedures and ethics of this research work were based on the "Code of Ethics for Scientific Research". They were authorized by letter Nº 002-GRJ-DRA-AAC-PERÚ-2022, dated August 20, 2022, and issued by the “Dirección Regional de Agricultura Junín”, in the section on ethics of animal use, in trout.

In addition, all research protocols were followed, with the permission and authorization of the company. Likewise, was conducted in accordance with international and national guidelines for the care and use of research animals.

Study Area

The study was carried out at the facilities of the aquaculture production center of SAIS "TUPÀC AMARU" Ltda. N°1, in the district of Canchayllo, province of Jauja, Junín region – Peru (Figure 1). Located at an altitude of 3575 m.a.s.l., with temperatures ranging from 8 to 12 °C and an average annual rainfall of 700 mm (Senamhi, 2023). The company has a production volume of 3.5 - 4 tons per month. Approximately 42 tons per year. The study was developed in two periods of the year: the rainy season (April - June) and the dry season (July - September) of the year 2021.

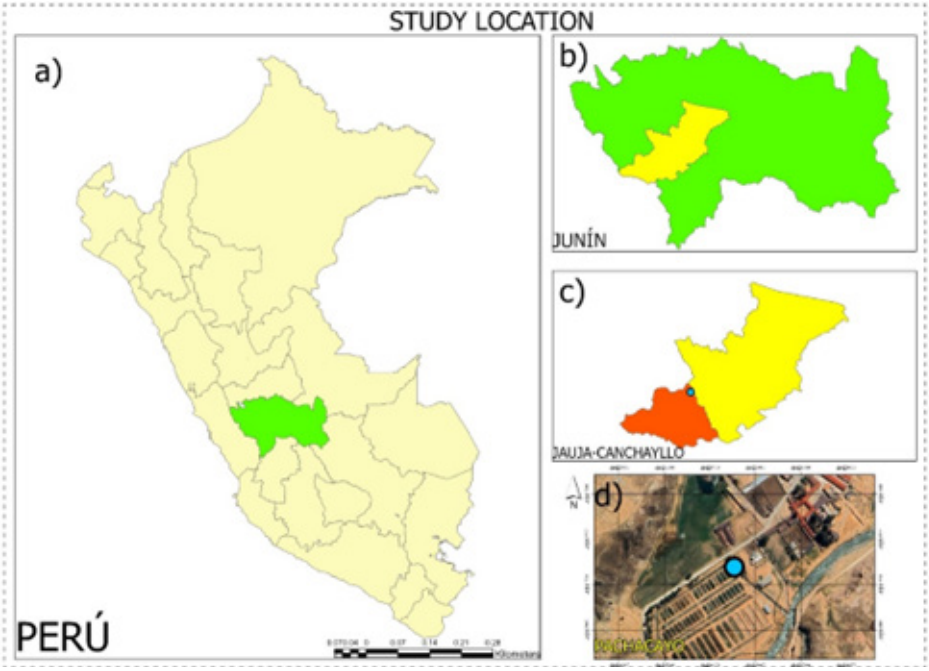

Figure 1 Location of study, (a) map of Peru by regions, green color, shows the Junin region. (b) map of the Junin region, yellow color, shows the province of Jauja. (c) map of the province of Jauja, orange color, shows the district of Canchayllo. (d) satellite shows the place of study, which belongs to the SAIS TUPAC AMARU Ltda N°1.

Animals and distribution

A total of 60 trout *(Oncorhynchus mykiss)* of commercial age (8 months) were studied, distributed in two groups: 30 for the rainy season and 30 for the dry season. Fed with commercial product Nicovita Classic Trout 5 (Table 1), a proximal analysis was performed (Mena-Pérez et al., 2021) The feed was evaluated at the Animal Nutrition Laboratory of the School of Animal Husbandry of the Universidad Nacional del Centro del Perú. The productive performance (length, live weight, carcass weight, and yield) and physicochemical performance (pH, acidity, water retention capacity, humidity, ash, ethereal extract, and protein) were evaluated.

Table 1 Feed supplied and nutritional value in the diet of trout in both seasons of the year

Product Composition	Season	
	Rainy	**Dry**
Product name: Nicovita Classic Trucha 5		
Protein (%)	44	44
Fat (%)	13	13
Ash (%)	14	14
Humidity (%)	12	12
Fiber (%)	3.2	3.2
Supply		
kg/day	**0.11**	**0.11**
Nutritional Value		
Protein (g)	48.4	48.4
Fat (g)	14.3	14.3
Ash (g)	15.4	15.4
Fibra (g)	3.52	3.52

[a]kg/day (55 gr in the morning and 55 gr in the afternoon), with a biomass of 4.5 kg and a feeding rate of 2.5 %, for 30 trout in rainy season and 30 trout in dry season.

Data collection

Productive performance: To evaluate the effects of the seasons, the trout were weighed individually on a model balance (DPCS-140), and then length measurements were taken (Figure 2) of the trout by adapting a tape measure. To obtain the yield, the carcass weight was divided by the live weight (Figure 2) and multiplied by 100 (Sobrinho et al., 2013). Subsequently, the slaughtered animals were transported in a thermal box (Figure 1) with ice cubes for refrigeration and preservation (Guo et al., 2001).

Physicochemical characteristics: For the determination of physicochemical performance (Figure 2) 10 g of trout meat was mixed with 10 ml of distilled water and measured with a pH meter (Crison Basic 20 calibrate) (Gonzáles-Fandos et al., 2004). Similarly, for the determination of acidity, 10 g of ground sample were deposited in a beaker, then transferred to an Erlenmeyer 250 ml where it was shaken and filtered then NaOH 0.1 N was added, and it was determined as a percentage by volume (ml) by normalization of the NaOH solution by 0.090 g/mol between the mass in grams of sample (Zumbado, 2020). To determine the water retention (WRC), the % of free water was determined as the final filter paper weight - the initial weight of filter paper, divided by the meso of the sample (3g) and the result multiplied by 100 (Viera et al., 2017), and then determine the WRC with a subtraction between 100 and % free waters (Segura et al., 2014). The determination of protein, ethereal extract, and ash was carried out with the apparatus Soxhelt (Figure 2) and the method Kjeldahl (Yasuhara and Nokihara, 2001; Coroian et al., 2015).

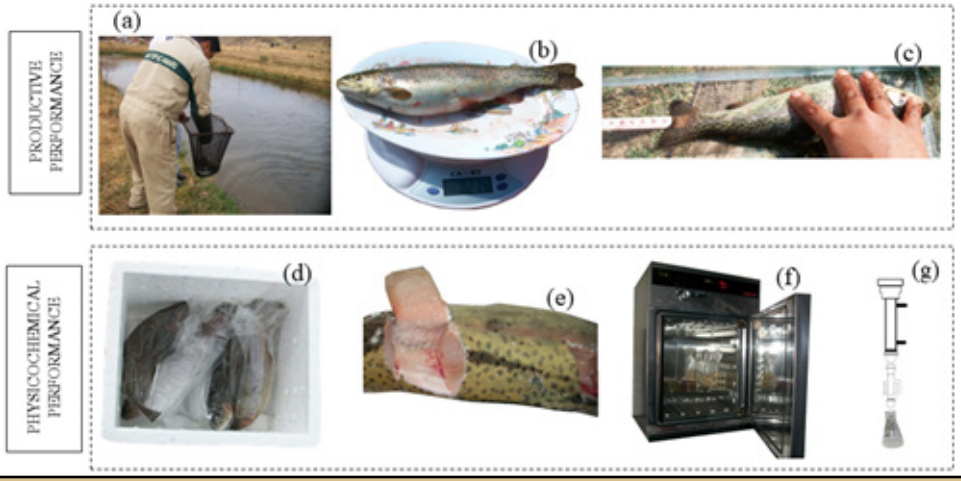

Figure 2 Methodology for data collection in both seasons in trout (Oncorhynchus mykiss). Productive performance: (a) trout were extracted from the fish farm of SAIS TUPAC AMARU; (b) weighing of biological samples; (c) length measurement. Physicochemical performance: (d) transfer to the laboratories; (e) 10 g meat sample; (f) incubations in the oven; (g) nutritional analysis with Soxhelt.

Statistical Analysis

The analyzed data were recorded and sorted in Microsoft Excel. Differences in the seasons (rainy and dry season) were carried out using analysis of variance (ANOVA), the means, maximums, minimums, and standard deviation were determined and subsequently, a post-hoc Tukey test was performed. A value of ($P<0.05$) was considered different. A value of $P<0.05$ was considered different, all statistical analyses were performed with CRAN R software (R Team Core, 2019), and version 4.3.0 (Kassambara and Mundt, 2017) was used.

RESULTS

Productive performance

From Figure 3A, it was evident that there were no significant differences ($P>0.05$) in length (cm) between the rainy and dry seasons with 25.10 ± 1.63 cm and 24.70 ± 1.06 cm, respectively, finding similarity between seasons. In contrast, for the live weight (g) variable (Figure 3B), highly significant differences ($P<0.05$) were found between the rainy and dry seasons with 239.67 ± 17.17 g and 186.30 ± 17.12 g, respectively. A higher live weight was found in the rainy season. Similarly, for the carcass weight variable (g) (Figure 3C), 186.30 ± 15.52 g and 140.77 ± 13.94 g were found for the rainy and the dry season, respectively. For the carcass yield variable (Figure 3D), differences ($P<0.05$) were also found for the rainy and dry seasons with 77.68 % and 75.52 %, respectively.

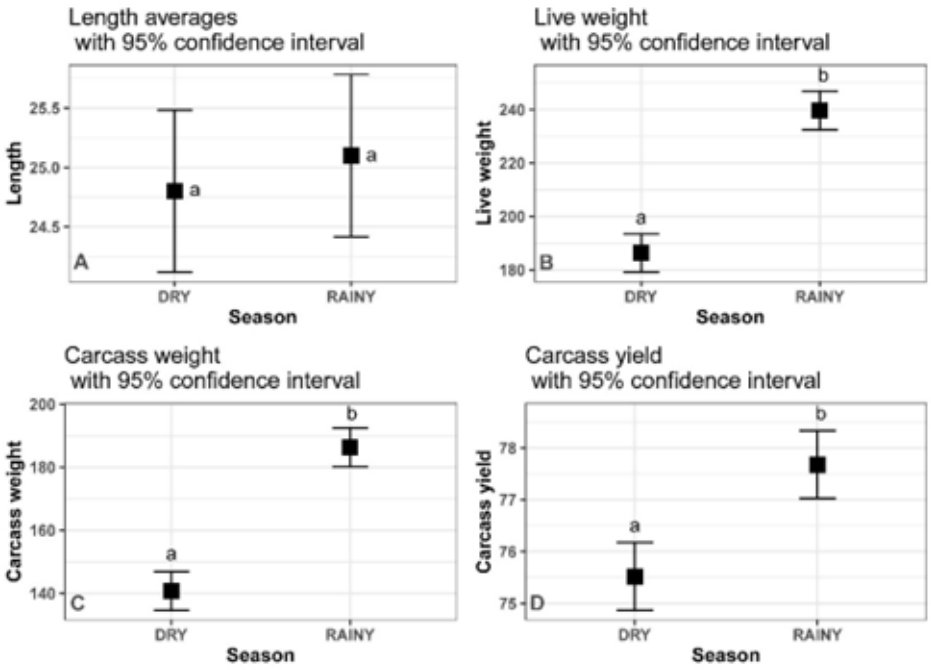

Figure 3 Production performance (a,b equal letters in the same column do not differ from each other at 95% by Tukey's post hoc test).

Physicochemical characteristics

From Table 2, for pH, differences ($P<0.05$) were reported in trout meat between the rainy season and dry season with 6.65 and 6.77 pH, respectively. In the same way (Table 2) For the water retention capacity (%), differences were found ($P<0.05$) with 48.38 and 51.73 for the rainy and dry seasons, respectively. Table 2 shows that acidity (%) with 1.11 and 1.12 for the rainy and dry seasons, respectively; humidity (%) with 75.20 and 75.87 for the rainy and dry seasons, respectively; ash (%) with 1.60 and 1.77 for the rainy and dry seasons, respectively; ethereal extract (%) with 4.20 and 3.73 for the rainy and dry seasons, respectively and protein (%) with 16.57 and 15.77 for the rainy and dry seasons, respectively there are no differences ($P>0.05$) between the rainy and dry seasons.

Table 2 Average physicochemical yields of trout in two seasons.

Performance	Rainy season	Dry season	P-value
Physicochemical			
pH	6.660 ± 0.090[b]	6.710 ± 0.050[a]	0.0173
Acidity (%)	0.073 ± 0.009[a]	0.077 ± 0.007[a]	0.1260
Water retention capacity (%)	48.380 ± 0.580[b]	51.730 ± 0.910[a]	0.0271
Humidity (%)	76.140 ± 0.780[a]	76.430 ± 0.920[a]	0.2000
Ash (%)	1.640 ± 0.073[a]	1.660 ± 0.067[a]	0.2530
Ether extract (%)	3.720 ± 0.290[a]	3.780 ± 0.350[a]	0.4960
Protein (%)	16.560 ± 0.180[a]	16.400 ± 0.430[a]	0.0670

[a,b] equal letters in the same column do not differ from each other at 95% by *Tukey's post hoc test*.

DISCUSSION

Productive performance

In Figure 2A, for the variable length (25.10 cm) and live weight (Figure 2B) (239.67 g), the best mean was found for the rainy season, this is consistent with that reported by Colque (2020) who mentions that at times when the temperature is below 10 °C, growth and production is higher; and a temperature of 8 °C has been reported in the research. Kalinak (2019) reported greater length in the rainy months. On the other hand, the results are also in agreement with Milukaite (2010) who mentions that there is better growth in riverine conditions. In the same way, the research is supported by the following Cefas (2004) who comments that trout perform better in rainy seasons. The live weight (g) is lower than that reported by Quispe (2022) who worked in ponds and with older trout. On the other hand, it is higher than the live weight reported by Villa (2021) who worked with similar diets, indicating that in the rainy season trout development is superior. Trout diets are important to gain weight and have weight according to the market, it should also be noted that it depends on the temperature and the ration (Pepe et al., 2012). Where better river conditions exist, these animals tend to improve their characteristics and production because they are aquatic animals; therefore, low rainfall periods will not bring good productive performance. (Hidalgo et al., 2010).

The results (Figure 2B) of carcass weight (186.30 g) and carcass yield (Figure 2C) (77.68 %) are similar to those reported by Macías et al. (2006) who worked with ten-month-old fish in three strains, carcass weights are economically important (García-Ballesteros, 2022), The results obtained for carcass yield are similar to those of several researchers, as well as for carcass weight. With respect to carcass yield, the results obtained are similar to those of several researchers, such as Blay et al (2021) who report a performance of 88.7 %, as well as García-Macías et al. (2004) with 87.15 % yield. These similarities are due to the fact that they worked with trout of the same origin; however, there are also authors who report lower percentages of trout of the same origin, like García-Macías et al. (2004) with 54.38 % and Royce (1996) with 70 %, due to the time of study, feeding, temperature, and age of evaluation. The percentage of eviscerated carcasses is a characteristic sought after in trout that correlates to the genetics of the trout. (García-Ballesteros, 2022), it is even mentioned that in fluvial seasons all these characteristics are superior (Milukaite, 2010) to the benefit of the producer. There is a clear advantage in trout production during the rainy season compared to the dry season.

Physicochemical characteristics

For pH (Table 2), we have found results related to the mentioned by Piamba-Mamian et al. (2020), who comment that a pH below 6.0 is considered a diseased animal. On the other hand, it is similar to that reported by Colque (2020) who evidenced a pH of 6.8, similarly, a pH of 6.8, Braun (2010) obtained a pH range of 6.5 - 6.9. The difference in pH in the trout meat for the rainy season (6.65) and dry season (6.77) is due to the alteration caused by the rains where the pH levels are altered (Sosa-Echevarría, 2018), being a little more acidic for the rainy season (Franco, 2018), this collaborates Love (1979) which

mentions that the pH varies according to the time of the year, these concepts explain the difference in pH of trout meat at different times of the year.

For Water holding capacity (%) (Table 2), similar results were obtained to those of Macías et al. (2006) which obtained water holding capacity ranges of 47.21 - 54.65 %. A high value of water holding capacity % does not mean that the meat is better (Amorano y Gambaruto, 1997; Venegas et al., 2008), the only difference found in the work is due to the season: in the rainy season, trout meat does not have good retention because there is water availability (Venegas et al., 2008), however, in the dry season, the animal tends to retain a higher percentage of water due to the lack of water. The season influences (Kaliniak, 2019) on these parameters.

Similar acidity (%), acidity (%), humidity (%), ash (%), ethereal extract (%), and protein (%) was evidenced (Table 2) for both seasons, these results are similar to the values reported by several authors, by Dinleski et al. (1994); Karakoltsidis et al. (1995); Weatherup and McCraken (1999); Kaliniak (2019), who mention that trout meat does not usually vary by management or production environment. However, these physicochemical characteristics will depend on age and feed. (Stanek, 2010). Therefore, there were no differences between the periods because they belonged to the same age and with the same feed.

CONCLUSIONS

The rainy season is an influential factor on productive performance; the trout improve their productive characteristics due to the abundance of water found during the rainy season, thus showing an influence on productive performance, an important fact for the benefit of many producers in Peru.

In terms of the physicochemical performance of trout meat, there was no evidence of any influence of the seasons (rainy and dry).

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CONFLICT OF INTEREST

There is no conflict of interest among the authors regarding the publication of this article.

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