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BIOLOGY

Impact of production chain on defects of farmed shrimp (*Penaeus vannamei*)

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ABSTRACT: The production chain of *Penaeus vannamei* require detailed quality evaluation from farm to processing plant, to maintain the quality standards. We evaluated the impact of production chain steps in main defects of *P. vannamei* as red hepatopancreas, detached cephalothorax and post-mult. Red hepatopancreas and detached cephalothorax exhibited the highest defect incidence, which are related to capture method and post-harvest handling procedures. Red hepatopancreas showed a positive correlation (r = 0.56; P = 0.008) with post-molts. The Principal Component Analysis (PCA) explained 53.91% of total data variance, where the second principal component (PC2) contributed with 19.39% separating shrimp defects and management steps based on square cosines of red hepatopancreas and transport time. These results suggested that steps of production chain as well as *post mortem* process are directly related to shrimp defects, and the knowledge of these factors can contribute to improve the product quality.
Key words: autolytic changes, shrimp defect analysis, detached cephalothorax, red hepatopancreas.

Impacto da cadeia produtiva sobre os defeitos do camarão de cultivo (*Penaeus vannamei*)

RESUMO: A cadeia produtiva do *Penaeus vannamei* exige avaliações detalhadas quanto à qualidade do produto desde o campo até a planta de processamento, considerando a importância da manutenção dos padrões de qualidade. Foi avaliado o impacto das etapas da cadeia produtiva nos principais defeitos do *P. vannamei* como hepatopâncreas vermelho, cefalotórax desprendido e pós-mudas. Hepatopâncreas e o cefalotórax desprendido foram os defeitos de maior incidência, e estão relacionados ao método de despesca e manuseio pós-abate. O hepatopâncreas vermelho apresentou correlação positiva (r = 0,56; P = 0.008) com pós-muda. A Análise de Componentes Principais (ACP) explicou 53,91% da variância total dos dados, onde o segundo componente principal (PC2) contribuiu com 19,39% separando os defeitos do camarão e as etapas de manejo com base nos cossenos quadrados do hepatopâncreas vermelho e tempo de transporte. Esses resultados sugerem que as etapas da cadeia produtiva bem como o processo *post mortem* estão diretamente relacionados aos defeitos dos camarões, e o conhecimento desses fatores pode contribuir para a melhoria da qualidade do produto.
Palavras-chave: alterações autolíticas, análise de defeitos do camarão, cefalotórax desprendido, hepatopâncreas vermelho.

The *Penaeus vannamei* is a farmed shrimp most traded around the world, and Brazilian Northeast region is responsible for 99.4% of total production in the country (IBGE, 2018). This species is known to its sensory quality, which make it attractive to consumer's purchase. Therefore, the production and commercialization of *P. vannamei* require quality evaluations throughout the production steps. Shrimp is a highly perishable seafood, due to their intrinsic and extrinsic characteristics, such as pH close to neutrality, accelerated *rigor mortis* and high-water activity (ANNAMALAI et al., 2015). In addition, stress conditions during management and production steps could contribute to the oxidative stress leading to shrimp fragility and rupture of organs cell membranes (LUCIEN-BRUN, 2006).

United States grading standards and procedures for grading of fresh shrimp (NOAA/USDC, 2021) considered as shrimp defects the "unacceptable heads" (described as detached cephalothorax or red hepatopancreas), "lack of uniformity" (small organisms), "black spot" (melanosis) and "broken or damaged" (THANASARN et al., 2019). Among shrimp defects, hepatopancreas color changes

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significantly reduces the commercial value of theproduct (LUCIEN-BRUN, 2006). Palanini et al. (2019) reported losses of US$ 0.9/kg for shrimp defects in post-harvest. Therefore, the aim of the present study was to evaluate the impact of production chain steps in main defects of *P. vannamei*.

Samples of *P. vannamei* were obtained from the reception sector of a fish processing unit from two shrimp farms: Farm 1 and Farm 2, located at 15 and 70 kilometers, respectively, from processing plant(Itarema, Ceará, Brazil). The shrimps were reared under the same production conditions, feeding management and harvest method (floodgates with BagNet® nets). The animals were slaughtered by hypothermia in water and ice and submerged at a solution with sodium metabisulfite (0,01%) to prevent melanosis. Shrimp samples were stored in ice boxes (ratio 1:1) and transported to processing plant. Data about harvesting time, cultivation time, time of transport to processing plant, average weight of shrimp and average weight of total harvested animals were collected from the "Certificate of Origin" filled out on the farm. The analysis of shrimp's defects was realized for 21 days. Samples of 1.0 kg were collected from the ice boxes, totalizing 7.478 shrimps. The defects were evaluated by observing the appearance of each unit sample and classified into six groups: I. post-moult (I and II); II. detached cephalothorax; III. red hepatopancreas; IV. broken or ruptured; V. small organisms (less than 4 grams); and VI. mild necrosis.

The variables analyzed in the production chain were harvesting time (min); transport time (min); average weight of shrimp (g); growing time (days) and total average weight harvested (Kg). These data were also collected during the same period of the defect analysis and then statistically analyzed with the defects found in shrimp samples. The defects incidence rates were calculated according to the incidence formula: Incidence = Defective shrimp / Total of shrimp x 100. Results were analyzed using Principal Component Analysis (PCA) and Pearson's correlation (XLSTAT Software™; Version 2014.5.03, Addinsoft, Inc., Brooklyn, USA).

Regarding shrimp defects, red hepatopancreas and detached cephalothorax exhibited the highest incidences among the specimens evaluated (Table 1) with 28.74% and 17.44%, respectively. The observed incidences could be attributed to rapid autolytic reactions, which are enhanced according to capture method and post-harvest handling procedures, as exposure to high ambient temperature for long period (GORNIK et al., 2010; ANNAMALAI et al., 2015).

Red hepatopancreas is associated to the presence of large amounts of crustacyanins, a complex of proteins and carotenoids from shrimp feeding (PARISENTI et al., 2011), which are released at high temperatures or enzymatic denaturation, contributing the appearance of red color (LOCO et al., 2018). Autolytic reactions are mainly responsible to the occurrence of detached cephalothorax (KIRSCHNIK & VIEGAS, 2004). The release of endogenous enzymes after post-mortem metabolism contributed to the decrease of head adhesion and to the highly incidence of cephalothorax defect (KIRSCHNIK & VIEGAS, 2004).

A positive correlation ($r = 0.56$; $P = 0.008$) was observed between red hepatopancreas and post-moult I and II, probably due to the autolysis of hepatopancreas, which occurs faster in crustaceans due to their high content of endogenous proteases (NIKOO et al., 2021). This correlation is associated to the soft-shelled and vulnerability of the shrimp after first and second moultings (LEMOS & WEISSMAN, 2021).

The Principal Component Analysis (PCA) explained 53.91% of total data variance (Figure 1). The first principal component (PC1) contributed to 34.52% of this variance and separated growing time, harvesting time, average shrimp weight and total harvesting weight. The second principal component (PC2) contributed to 19.39% of the variance. Despite the lower percentage, this component separated the shrimp defect and management steps based on square cosines of red hepatopancreas and transport time.

The findings of the present study indicate that the main defects of *P. vannamei* could be attributed to rapid autolytic reactions which are enhanced according to capture method and post-harvest handling procedures. These results suggested the necessity to develop suitable processing strategies to improve the capture method and post-harvest

Table 1 - Incidence of shrimp (*Penaeus vannamei*) defects.

Shrimp defects	Incidence %
Red hepatopancreas [1]	28.74
Detached cephalothorax[2]	17.44
Post-moult (I and II)[3]	2.54
Broken or ruptured[4]	0.31
Mild necrosis[5]	0.24
Small organisms[6]	0.07

[1]Organ located in the cephalothorax presenting red coloration; [2]cephalothorax/head partially or completely detached from the abdomen; [3]stages of the recovery phase of cyclic exoskeleton exchange; [4]mechanical damages along the abdomen; [5]necrosis usually caused by ante-mortem injuries; [6]specimens weighing much less than commercial standards.

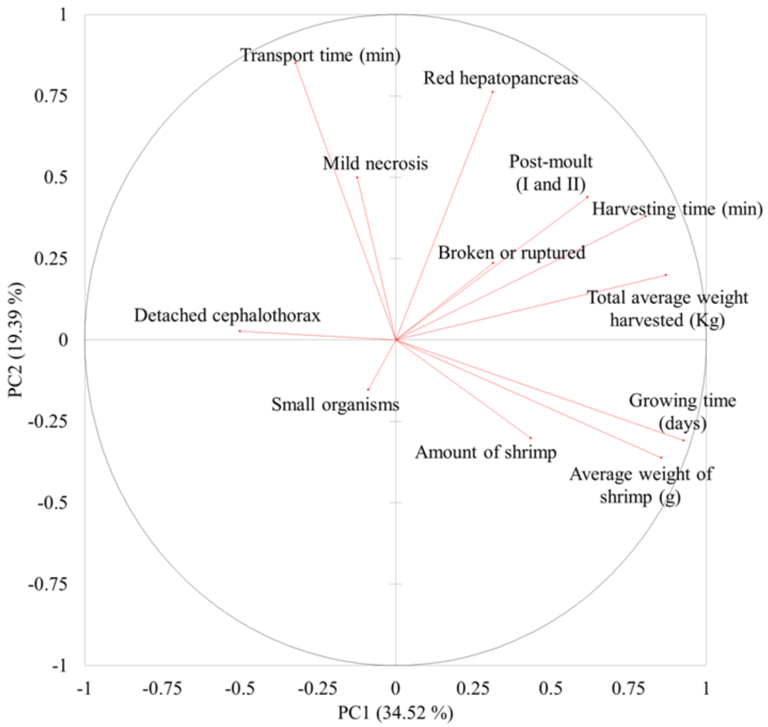

Figure 1 - Principal Component Analysis (PCA) of shrimp (*Penaeus vannamei*) defects analyzed during 21 days under conditions of the stages of production chain.

management procedures in order to improve shrimp quality and minimize economic losses.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

We authors of the article entitled Impact of production chain on defects of farmed shrimp (*Penaeus vannamei*) declared, for allpurposes, the project has not been submitted for evaluation to the Ethics Committee of the Universidade Federal Fluminense, but we are aware of the content of the Brazilian resolutions of the National Council for Control of Animal Experimentation - CONCEA “http://www.mct.gov.br/index.php/content/view/310553.html” if it involves animals.

Thus, the authors assume full responsibility for the presented data and are available for possible questions, should they be required by the competent authorities.

AUTHORS' CONTRIBUTIONS

The authors contributed equally to the manuscript.

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Erratum

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