Evaluating the efficacy of some plant extracts in enhancing the quality of chilled Japanese shrimp (Marsupenaeus japonicus) and controlling histamine formation.

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ARTICLE INFO

Keywords
- Shrimp
- plant extracts
- histamine
- fish

ABSTRACT

Nowadays, the customer’s approach towards naturally preserved fish meat products has gained interest in overcoming the health risks of synthetic preservatives. So, our investigation aimed to study the effectiveness of natural preservatives for controlling histamine formation and spoilage in chilled shrimp. The potential of moringa extract (MOE), green tea extract (GTE), and olive leaf extract (OLE) (1.5% for each) to act as antioxidants in shrimp was evaluated. The histamine values recorded in the control group significantly differed from MOE, GTE, and OLE (p < 0.05) throughout the days of chilled storage. These findings emphasized the effect of the plant extracts to extend the shelf life of chilled shrimp and improve sensory attributes (color, odor, texture, and overall acceptability) and physicochemical characteristics (pH, TBA, and TMA) during a storage period of up to 14 days under refrigerated storage (4°C). These findings suggest that the extract, especially olive leaves, may serve as a food additive, extending the shelf life of shrimp.

1. INTRODUCTION

Shrimp has become popular among consumers as a component of a healthy diet because they are rich in high-quality protein, essential amino acids, and vitamins in addition it is low in fat (Qiao et al., 2019). However, shrimp are highly susceptible to deterioration during transportation, storage, and marketing, which results in a loss of nutrients and a decrease in quality (Ye et al., 2020). Shrimp is a highly perishable that spoils rapidly during processing and cold storage (Rossi et al., 2002; Edris et al., 2017), threatening food safety (Biji et al., 2016).

Japanese shrimp (Marsupenaeus japonicus) is a high-quality dietary protein source but it’s also a critical allergenic food. The food allergy (FA) caused by shrimp has become a worldwide public health concern with anaphylaxis risk (de Silva et al., 2022). The extracellular protease of spoilage microorganisms breaks down fish meat into small molecules of amino acids (AA) and oligopeptides, which are used as fuel for the fast growth of the spoilage microorganisms (Yu et al., 2018). Also, Trimethyl-Amine-N-Oxide (TMAO) is reduced to trimethylamine (TMA) (Wright et al., 2019). During these spoilage steps, spoilage microorganisms can use AA as energy for metabolic growth and diamine or decarboxylate FAA to form ammonia and BAs (Zhuang et al., 2021). The accumulation of ammonia and BAs induces rapid deterioration of fish quality, such as increased pH values and total volatile salt nitrogen, off-flavors, and even the outbreak of food-borne diseases (Erikson et al., 2011). Histamine poisoning is one of the main public health concerns (Yang et al., 2021). Its consumption causes toxicity and food-borne illnesses such as digestive disturbances, hives, and difficulty breathing, and may cause death (FDA, 2001). EC regulations (EC/1441, 2007) set a limit for 100 mg/kg of histamine in fish products. So, accurate and sensitive evaluation of histamine in fish and fish products becomes a demand. HPLC is one of the most sensitive and accurate protocols for histamine detection (Altieri et al., 2016). Moreover, histamine’s risk is related to its resistance to detoxification by normal freezing and heat treatment methods such as frying and broiling (Akbari-Adergani et al., 2012). However, limited research on histamine screening using immunoassay has been reported (Xu 2020). Yang et al. (2021) recommend the indirect competitive ELISA as an accurate and sensitive protocol for routine histamine screening in seafood.

Many researchers worldwide seek promising natural preservatives with excellent antioxidant and antimicrobial activity for extending the shelf life of seafood products (Olatunde and Benjakul, 2018). Moringa oleifera (M. oleifera) is a substantial source of natural antioxidants because it has been employed as a good source of rare flavonoids and phenolic acids (Dhakad et al., 2019). Li et al. (2018) stated that green tea primarily comprises polyphenols. Excellent sources of polyphenols can be found in green tea extract, making them a potent substitute for artificial antioxidants. Since they are natural, they are usually less dangerous and seem to have a similar impact on oxidation inhibition (Manea et al., 2014). Extract from olive leaves (OL) has been shown to exhibit antioxidant properties (Kuley et al., 2017). So, the aim of this study was to assess the efficacy of some plant extracts (Moringa oleifera (MO),

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green tea (GT), and Olive leaves (OL) extracts) on aspects of shrimp quality, shelf life and toxic histamine biogenic amine formation.

2. MATERIAL AND METHODS

Preparation of extracts
Ethanol extracts from olives, green tea, and Moringa oleifera leaves were prepared according to Abdel-Daim et al., (2020) as following: Leaves from each plant were collected, washed, dried, and crushed to a fine powder using a milling machine. Ethanolic extract of the powder was prepared in absolute 99.8% ethanol solution (for 48 hours) and then filtered (3 times) on 2 mm-sized pores filter paper.

HPLC screening of the phenolic profiles of leaf extracts
The phenolic profile of Moringa oleifera (MO), green tea (GT), and olive leaf (OL) extracts was evaluated following Hamad et al., (2023). The phenolic compound of each extract was separated by an Eclipse C18 column and then screened using the Agilent 1260 Infinity HPLC Series, USA.

Shrimp preparation
Fresh medium-sized chilled shrimp (Marsupenaeus japonicus) from local supermarkets were collected and washed in a distilled water bath for just one minute. To evaluate the impacts of plant extracts on shrimp, samples were dipped in previously prepared plant extracts as following: control group (without application of any extracts on shrimp), MO group (shrimp + 2% MO extract), GT group (shrimp + 2% GT extract), and OL group (shrimp + 2% OL extract). Samples were packed in polyethylene bags and kept refrigerated at 4 °C for 14 days and examined periodically every two days starting from the zero day of the experiment (Zero, 2nd, 4th, 6th, 8th, 10th, 12th, and 14th). Trials were triplicated, and mean values were statistically monitored and interrupted.

Biochemical quality
Lipid oxidation of the chilled shrimp resembled TBA was evaluated by spectrophotometry to be expressed by the malonaldehyde content of samples. All previous chemical quality tests were screened using the Agilent 1260 Infinity HPLC Series, USA. The phenolic profile of Moringa oleifera (MO), green tea (GT), and Olive leaves (OL) extracts was evaluated following Hamad et al., (2023). The phenolic compound of each extract was separated by an Eclipse C18 column and then screened using the Agilent 1260 Infinity HPLC Series, USA.

ELISA screening of histamine
Histamine residue in different groups was screened using ELISA following Sadeghi et al., (2019), using RIDASCREEN® Histamine ELISA (R-Biopharm, Darmstadt, Germany). Samples from each group were prepared and homogenized, and a concentration of 1:10 de-ionized water was prepared. Solutions were centrifuged at 2500 RPM for 5 min until 3 phases were formed. After discarding the oily phase, the aquatic phase was diluted in de-ionized water. ELISA kits were used, and binding between acylated samples and acylated histamine with the coated antibody was performed. Enzyme-conjugated antibodies were applied and then washed. The absorbance of samples was read at 450 nm on a microplate reader (BioTek®, PMT 49984, U.S.A.).

Sensory evaluation
Sensory attributes of chilled shrimp (texture, odor, color, and overall acceptability) were evaluated following Rong et al., (2009).

Statistical analysis
Results obtained were statistically analyzed using two-way analysis of variance (ANOVA) by Graph Pad Prism 8.0.2. Statistical analyses were performed to study the influence of different herbal extracts as well as storage periods on the quality of chilled shrimp. Results were expressed as the mean ± SD of three triplicates (Greenhouse and Geisser 1959).

3. RESULTS

A Detailed Phenolic profile for different leaves extract, obtained by HPLC screening, was illustrated in table (1) and figure (1). It was found that OL extract enriched with Oleuropein with a conc. of 17680.880 ug/ml. concerning GT extract, the higher phenolic compound in it was epigallocatechingallate (1354.432 ug/ml), followed by epicatechingallate (280.004 ug/ml) and caffeine (1338.341 ug/ml). Rutin (398.26 ug/ml) was the higher phenolic compound in MO.

Results in figure (2) showed the effect of the examined extracts applied on chilled shrimp to evaluate its impacts on physico-chemical, and the significance variation (P < 0.05) between physicochemical characters of chilled shrimp in control and those in treated with natural plant extracts. Extracts of OL showed the higher impacts on enhancing values of pH, TBA and TMA that reflect freshness of chilled shrimp samples and shelf life of it. As, control group showed higher values of pH, TBA, TMA reflects its incipient spoilage from day 4th of refrigerated storage, while treated samples with MO, GT, OL stayed within accepted range till 14th day of refrigerated storage.

Concerning sensory attributes of chilled shrimp, results in fig. (3) showed the impacts of MO, GT, and OL extracts on sensory characters (texture, odor, color, and overall acceptability) and shelf life of chilled shrimp. Results in figure (4) showed that MO, GT, and OL extracts positively reduced formation of histamine levels in chilled shrimp all over storage period (14 days), compared to that of control untreated group.

Table 1 Phenolic profiles of MO, GT, and OL extracts by HPLC-DAD.

<table>
<thead>
<tr>
<th>Phenolic compound</th>
<th>MO concug/ml</th>
<th>GT concug/ml</th>
<th>OL concug/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallic acid</td>
<td>6.786</td>
<td>39.815</td>
<td>39.303</td>
</tr>
<tr>
<td>Protocatechuic acid</td>
<td>3.380</td>
<td>12.439</td>
<td>89.887</td>
</tr>
<tr>
<td>Polyhydroxybenzoic acid</td>
<td>0.000</td>
<td>7.122</td>
<td>1.287</td>
</tr>
<tr>
<td>Gentisic acid</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Catechine</td>
<td>7.412</td>
<td>280.004</td>
<td>62.740</td>
</tr>
<tr>
<td>Chlorogenic acid</td>
<td>0.000</td>
<td>45.800</td>
<td>0.900</td>
</tr>
<tr>
<td>Caffeic acid</td>
<td>9.165</td>
<td>0.784</td>
<td>0.000</td>
</tr>
<tr>
<td>Caffeine</td>
<td>0.000</td>
<td>1338.341</td>
<td>0.000</td>
</tr>
<tr>
<td>Syringic acid</td>
<td>153.086</td>
<td>2946.000</td>
<td>19.764</td>
</tr>
<tr>
<td>Vanillyl acid</td>
<td>80.434</td>
<td>0.000</td>
<td>2.594</td>
</tr>
<tr>
<td>Ferulic acid</td>
<td>2.484</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Sinapic acid</td>
<td>3.044</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Pcinamic acid</td>
<td>2.673</td>
<td>15.799</td>
<td>3.442</td>
</tr>
<tr>
<td>Rutin</td>
<td>195.511</td>
<td>87.884</td>
<td>31.067</td>
</tr>
<tr>
<td>Hesperidin</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Naringin</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Oleuropein</td>
<td>0.000</td>
<td>0.000</td>
<td>17680.880</td>
</tr>
<tr>
<td>Apigenin-7-glycoside</td>
<td>11.884</td>
<td>9.088</td>
<td>0.000</td>
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<tr>
<td>Apigenin</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Cinnamic acid</td>
<td>1.900</td>
<td>5.016</td>
<td>1.135</td>
</tr>
<tr>
<td>Quercetin</td>
<td>1.432</td>
<td>2.778</td>
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<td>Kaempferol</td>
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<td>1.596</td>
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<tr>
<td>Chrysin</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Epigallocatechingallate</td>
<td>0.000</td>
<td>378.266</td>
<td>0.000</td>
</tr>
<tr>
<td>Epicatechingallate</td>
<td>0.000</td>
<td>1354.432</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Higher phenolic content MO, GT, and OL extracts highlighted their roles as antioxidants and helped to explain the study’s findings, according to a thorough phenolic profile for several leaf extracts that were acquired by HPLC screening. Similar findings were made by Hazra et al. (2012), who recorded that M. oleifera is one of the most important sources of natural antioxidants and antimicrobial agents because of the presence of many different types of antioxidant components in its leaves, including flavonoids, ascorbic acid, carotenoids, and phenolics. This, in turn, increases the shelf life of foods containing fat (Ali-Juhaimi et al., 2001). Additionally, green tea leaf extract is abundant in flavonoid (Jeyakumari et al., 2021). Furthermore, according to Lee and Lee (2010), oleanuropein, luteolin, diosmetin, rutin, verbascoside, apigenin-7-glucoside, and diosmetin-7-glucoside are the main physiologically active compounds of OL. Other notable compounds include hydroxytyrosol, tyrosol, caffeic acid, p-coumaric acid, vanillic acid, and vanillin.

In the challenge, results showed the significance of the positive impacts of plant extracts (MO, GT, and OL) on the physico-chemical characteristics (pH, TBA, and TMA) of chilled shrimp. These results agree with those by Elsabagh et al. (2023) in chilled tuna using natural plant extracts. Additionally, Jeyakumari et al. (2021) examined the impact of green tea extract on the biochemical and sensory quality of fish nuggets and found that the treated groups’ pH and TMA values slowly changed over time, indicating a significant increase in the shelf life of fish nuggets stored at 2°C. Green tea extract’s antioxidant properties are mostly attributable to the presence of polyphenols, particularly catechin (Abdel-Rahman et al. 2011). It has been thoroughly investigated how the presence of phenolic content affects the antioxidant action of green tea extract (Heim et al. 2002). Due to their potential to act as antioxidants, OL has become more and more in demand in recent years for usage in foods, food additives, and functional foods (Lafka et al. 2013). TMA is considered a marker for fish spoilage that increases in spoiled fish (Feng et al. 2017). During spoilage, trimethylamine oxide (TMAO), choline, and betaine are converted to TMA, which starts to increase gradually and indicates the spoilage of samples (Zhao et al. 2019). The TMA values of the control group significantly increased, while in the treated groups, plant extracts delayed the formation of TMA during the 14th day of storage.

OL extracts showed higher results in enhancing the physico-chemical attributes (pH, TBA, and TMA) of chilled shrimp; this agrees with those by Lahreche et al. (2022), who applied OL to chilled tuna fillets. Elsabagh et al. (2023) also improved the physicochemical properties of fish products by coating them with edible plant extracts. Also, Mansour et al. (2023) revealed that the phenolic compounds present in natural herbal extracts have an antioxidant effect and delay spoilage when incorporated into food.

Concerning sensory attributes of chilled shrimp, results in Table 3 showed the impacts of MO, GT, and OL extracts on sensory characters (texture, odor, color, and overall acceptability) and shelf life of chilled shrimp. A significant variation between the control (untreated) and treated groups revealed enhancement of the overall acceptability of chilled shrimp until the 14th day of refrigerated storage. OL extracts showed higher results in enhancing the sensory attributes and shelf life of shrimp than MO and GT extracts; this agrees with those by Lahreche et al. (2022), who applied OL to

4. DISCUSSION

Nowadays, the customer’s approach towards naturally preserved fish meat products has gained interest in overcoming the health risks of synthetic preservatives. In this study, the impact of some plant extracts on shrimp quality was evaluated.
chilled tuna fillets. Additionally, Jeyakumari et al. (2021) found that treating fish nuggets with green tea extract improved their sensory qualities and shelf life. They noted that up to the ninth day, there was a significant difference ($p < 0.05$) in texture value between the GTE-treated and control groups. It might be because additional connections or cross-linkages between protein molecules and phenolic compounds, which limit the flexibility of the protein aggregates, cause the gels to become less springy and more rigid (Ranendra et al. 2017).

One of the targets in this study was to control toxic histamine biogenic amine formation in chilled shrimp. The higher impacts on histamine caused by OL extracts may be due to active antioxidants (phenolic and flavonoid compounds), as illustrated by HPLC screening. These results agree with those recorded by previous authors for controlling histamine formation in fish using natural plant extracts, such as Elsabagh et al. (2023) and Nitta et al. (2016).

Nowadays, the customer’s approach towards naturally preserved fish meat products gained interest to overcome health risks of synthetic preservatives. In this study impact of some leaves plant extracts on shrimp quality was evaluated. Higher phenolic content MO, GT, and OL extracts highlighted their roles as antioxidants and also help to explain the study’s findings, according to a thorough phenolic profile for several leaf extracts that was acquired by HPLC screening. Similar findings were made by Hazraet et al. (2012), who recorded that *M. oleifera* is one of the important sources of natural antioxidants and antimicrobial agents because of the presence of many different types of antioxidant components in its leaves, including flavonoids, ascorbic acid, carotenoids, and phenolics. This, in turn, increases the shelf life of foods containing fat (Al-Juhaimi et al. 2001). Additionally, green tea leaf extract is abundant in a component called a flavonoid (Jeyakumari et al. 2021). Furthermore, according to Lee & Lee (2010), oleuropein, luteolin, diosmetin, rutin, verbascoside, apigenin-7-glucoside, and diosmetin-7-glucoside are the main physiologically active compounds of OL. Other notable compounds include hydroxytyrosol, tyrosol, caffeic acid, p-coumaric acid, vanillic acid, and vanillin.

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One of the targets in this study was to control toxic histamine biogenic amine formation in chilled shrimp. The higher impacts on histamine caused by OL extracts may be due to active antioxidants (phenolic and flavonoid compounds), illustrated before by HPLC screening. These results agree with results recorded by previous authors for controlling histamine formation in fish using natural plant extracts as Elsabagh et al., (2023) and Nitta et al., (2016).

5. CONCLUSIONS

Results of this study concluded that plant leaf extracts of MO, GT, and OL positively impact all aspects of chilled shrimp quality, including physicochemical, sensory, and control risks of toxic histamine formation. OL extracts proved to be higher in potency than those of MO and GT extracts. Plant extracts are considered promising natural additives that can be safely applied in the fish meat industry.

6. REFERENCES


