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Development of Plant Extracts Based Indicator for Monitoring Quality of Fresh Chicken Meat During Storage at Room Temperature (25±1° C)

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ABSTRACT

An experiment was conducted to develop a plant extracts based quality indicator for monitoring aerobically packed chicken meat quality during storage at room temperature (25±1ºC) until spoiled. Ripen black mulberry (*Morus nigra*) fruit extracts containing anthocyanins was used for developing quality indicator. Filter paper based indicator was exposed to the closed fresh meat environment. Changes in the indicator color and different quality parameters of chicken meat *viz*., total volatile basic nitrogen (TVBN), ammonia level, pH, sensory attributes and instrumental color values were evaluated and were correlated with color changed of indicator. During storage meat become visibly spoiled on 5th day of storage where as the color of the indicator changed gradually from red on 1st day to light green between 2nd-4th day and finally dark yellow on 5th. Both Total volatile basic nitrogen (TVBN) and ammonia level increased significantly ($P<0.5$) during storage. The pH value of meat increased significantly ($P<0.5$) from 5.4 to 6.1 during storage. Sensory attributes score for color, general appearance and acceptability decreased significantly ($P<0.5$) throughout the storage period. Lovibond Tinto meter color value for redness, yellowness, hue and chroma decreased during storage period. On the basis of results observed it might be concluded that the developed quality indicator is expected to provide a convenient aid to monitor the quality and shelf life of chicken meat during storage at room temperature.

Keywords: Black mulberry extracts, indicator sensor, total volatile basic nitrogen, meat pH, fresh chicken meat quality

Every food product needs some sort of packaging for its existence during transportation, handling, storage and use. The package is used to protect the product against the deteriorative effects of the external environment, communicate with the consumer as a marketing tool, provide the consumer with greater ease of use and time-saving convenience, and contain products of various sizes and shapes (Yam *et al*., 2005). Increasingly hectic lifestyles are creating new consumer demands from products and packaging, particularly in terms of user convenience (Butler, 2004). Therefore, monitoring the food quality during transport and storage in the production chain gives additional information for better predicting the product quality and can give important information for logistic control of the chain. This goal can be achieved by the use of intelligent packaging system and intelligent sensing. Intelligent food quality indicator sensors are increasingly used cost efficiently, quickly and non-destructively to determine the physiological status and quality of perishable products as well as to evaluate technical procedures on the basis of physical measurements.

Meat and meat products are highly prone to spoilage due to bacterial contamination (Gram *et al*., 2002). Eating such spoiled or contaminated meat can cause severe health hazards. Intelligent packaging applications have been used for monitoring spoilage of meat and to predict its shelf life. Intelligent packaging based quality indicators in meat packaging can effectively monitor the volatile organic compounds and gas molecules produced during meat spoilage (Vanderroost *et al*., 2014). Both petro-chemical and bio-based materials can be used to develop quality indicator although the bio-based material is generally more compatible for food-contact applications since it has eco-friendly attributes and higher consumer acceptance (Botrel *et al*., 2007). Some natural pigments from fruits and vegetable sources, anthocyanins for example, have great potential as indicators in intelligent packaging systems because the color expression of anthocyanins is strongly influenced by its structural conformation which is highly influenced by its pH. This color instability of anthocyanins makes these pigments especially useful as a tool to monitor food quality and therefore can be used as an indicator of food spoilage in intelligent packaging systems. On the basis of the color changing principle of anthocyanins in crude extracts, the present study was designed to explore the potentiality of black mulberry (*Morus nigra*) fruit extracts as quality indicator and to develop an intelligent packaging sensor for quality monitoring of fresh chicken meat during storage at room temperature (25±1° C).

MATERIALS AND METHODS

Development of indicator sensor

Fresh, ripen black mulberry fruits were collected from the gardens of Indian Veterinary Research Institute, Izatnagar campus and adjoining area. Crude extracts of fruit was made by following the method of Metivier *et al*. (1980). At the rate of, 15 g of fruits were finely minced in pastel and mortar by adding 10 ml of 1% HCl-ethanol. The mixture slurry was transferred in a centrifuge tube and kept overnight in refrigerator wrapping in alluminium foil for proper extraction. Next day, it was centrifuged for 15 min at 5000 rpm. Supernatant crude solution thus obtained was transferred to an amber color bottle and kept in refrigerator for further use. Filter paper (Whatman® No. 42) strip of 2 cm × 2 cm square shape was prepared as base material for the sensor. The filter paper strips were dipped into the crude extracts and put for 30 sec. The developed indicators were conditioned over night at refrigeration temperature (4±1º C) in alluminium foil covered petridish.

Evaluation of color change response of indicator

The changes in color of indicator was evaluated by exposing indicators to the fresh chicken meat (100g) environment by sticking inside the lid of sterile petri dishes (90 mm diameter) and closing them tightly with parafilm®. The chicken meat packets attached with indicator were stored at room temperature (25±1) ºC for the period of 5 days. Changes in the color of the indicators were recorded by digital camera (SX160 IS, Canon, India).

Estimation of TVBN, Ammonia level and pH value of stored chicken

The produced TVBN conc. of fresh chicken meat during storage was determined by micro-diffusion technique according of Pearson (1968). The ammonia level in meat during storage period was evaluated by following the method prescribed by Sastry *et al*. (1999). pH estimation was performed by following the method of Trout *et al*. (1992).

Sensory evaluation

Sensory evaluation of chicken meat during storage period was evaluated on the basis of color, general appearance and acceptability. About 10 g meat sample kept in sterile petri dishes covered with parafilm® were taken out from storage conditions. Then the samples were subjected to sensory evaluation in quadruplicates by trained panelists. Changes in sensory attributes were judged by a panel of seven trained members using five point scale.

Instrumental color (Lovibond Tintometer color values) and sensory evaluation

The instrumental color value was estimated by using Lovibond Tintometer (Model F, Greenwich, UK). Finely chopped meat sample was placed in the sample holder of Lovibond Tintometer. The red (LTCU 'R') and yellow (LTCU 'Y') color units were recorded by matching sample color by adjusting (a*) red and (b*) yellow units, while keeping the blue unit fixed at 1.0. The hue and chroma of meat were determined using the formula $\tan^{-1}(b/a)$ and $(a^2 + b^2)^{1/2}$, respectively, where a = red unit and b = yellow unit (Little, 1975; Froehlich *et al*., 1983).

Statistical analysis

The experiment was replicated three times and the data generated were analyzed by statistical methods of one way ANOVA, Mean±S.E using SPSS software package developed as per the procedure of Snedecor and Cochran

(1995) and means were compared by using Dunkan's multiple range test (Dunkan, 1955).

RESULTS AND DISCUSSION

Changes in color of indicator

Inside the packet of fresh chicken meat volatile basic gases were produced during its storage at 25±1º C, which might have caused the color change of indicator from red to light green to yellow at the end of 5th days of storage (Fig. 1) as compared to the control indicator which were attached outside the packet and was not exposed to the meat environment, remained with unchanged red color.

Correlation of color changes in indicator with changes in physico-chemical quality of chicken meat

The pattern of color change in quality indicator sensor in chicken meat packets was compared with the changes in three quality attributes viz., total volatile basic nitrogen (TVBN), ammonia level and pH of chicken meat.

In present study it was observed that the sensor gradually changed its color from red to yellow at the end of 5th day storage (Table 1), which correlates the significantly ($P<0.5$) increasing level of both TVBN and ammonia. The increase in TVBN during the storage period was might be due to break down of protein and deamination of amino acids leading to production of ammonia and other volatile bases. Similarly increasing level of TVBN content of beef was observed by Byun *et al*. (2003).

Significantly ($P<0.5$) increasing level of ammonia was also observed during storage which showed a positive correlation with the color change of sensor from red to yellow (Table 1). The increasing ammonia level of ammonia is agreeing with the findings of flank and Mcguire (1919). The increasing level of ammonia concentration during the storage was due to deamination of amino acid by microbes as a source of energy after the availability of glucose declined (Shukla, 2013).

The change in pH of chicken meat was positively correlated with the color change in sensor (Table 2). On the 1st day the pH of fresh chicken was 5.4 which decreased to 5.3 on second day of storage thereafter an increasing trend of pH has been observed which reached finally to 6.1 on the 5th day of storage.

A similar observation for fresh pork has also been given by Huang and Liu (2010). At preceding time storage, the pH of the samples decreased, and then pH increased until alkaline at the end of time storage. The decrease of pH may caused by the amount of lactic acid in meat. The increase of pH may be attributed to the accumulation of alkaline compounds such as ammonia and amino sugar complex and lipid (Jay and Shelef, 1978).

Table 1: Changes in physico-chemical attributes of chicken meat stored at room temperature (25±1º C)

Storage day	1st day	2nd day	3rd day	4th day	5th day
TVBN (mg/100g)	5.6±0.60^{d}	9.70±0.81^{c}	14.0±0.80^{b}	17.73±2.33^{a}	20.53±3.81^{a}
Ammonia (mg/100g)	11.24±1.46^{d}	16.80±1.61^{c}	25.2±2.46^{b}	32.66±1.23^{a}	36.40±0.93^{a}
pH	5.4±0.26^{e}	5.3±0.33^{de}	5.7±0.21^{bc}	5.9±0.71^{ab}	6.1±0.20^{a}

Means with different superscripts in a row differ significantly ($P<0.05$), n=8

Table 2: Changes in sensory evaluation scores of chicken meat stored at room temperature (25±1º C)

Storage day	1st day	2nd day	3rd day	4th day	5th day
Color	4.81 ± 0.14^{a}	4.41 ± 0.11^{b}	4.08 ± 0.06^{bc}	3.88 ± 0.13^{c}	2.42 ± 0.21^{d}
General appearance	4.91 ± 0.09^{a}	4.61 ± 0.13^{ab}	4.17 ± 0.26^{bc}	4.10 ± 0.28^{c}	2.16 ± 0.20^{d}
Acceptability	4.83 ± 0.04^{a}	4.42 ± 0.05^{bc}	4.19 ± 0.20^{cd}	3.98 ± 0.34^{d}	2.10 ± 0.35^{e}

Means with different superscripts in a row differ significantly ($P<0.05$), n=21

Table 3: Changes in Lovibond Tintometer color units of chicken meat stored at room temperature (25±1º C)

Storage day	1st day	2nd day	3rd day	4th day	5th day
Redness	2.90 ± 0.11^{a}	2.63 ± 0.24^{ab}	2.49 ± 0.25^{bc}	2.43 ± 0.23^{cd}	2.4 ± 0.23^{d}
Yellowness	3.26 ± 0.03^{a}	3.07 ± 0.08^{ab}	2.86 ± 0.08^{bc}	2.63 ± 0.17^{cd}	2.46 ± 0.12^{d}
Hue	48.44 ± 0.88^{a}	49.60 ± 1.85^{ab}	49.17 ± 2.10^{b}	47.36 ± 1.7^{cd}	45.96 ± 1.3^{d}
Chrome	4.37 ± 0.09^{a}	4.05 ± 0.21^{ab}	3.80 ± 0.22^{bc}	3.58 ± 0.27^{cd}	3.44 ± 0.24^{d}

Means with different superscripts in a row differ significantly (P<0.05), n=8

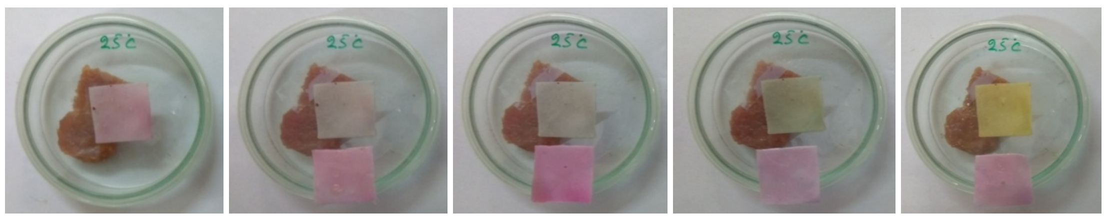

Fig. 1: Color changes of indicator during storage of chicken meat packets stored at room temperature (25±1º C) (1st day, 2nd day, 3rd day, 4th day, 5th day)

Correlation between the progressive quality deterioration of stored fresh chicken with sensory evaluation

It has been observed that the quality of meat deteriorates with the progression of storage period, which is reflected by lower scores of sensory attributes by trained sensory panelists. Here in the study, the sensory scores (Table 2) for chicken meat color, general appearance and acceptability decreased significantly (P<0.05) with change in color of the quality indicator. On 1st day of storage the ‘characteristics grayish pink, of chicken meat was perceived by the panelists. The color changed significantly on 3rd day of storage and therefore decreased score was observed. On 5th day of storage a significant (P<0.05) decrease in color score was recorded and was probably due to rapid increase in microorganisms invading the meat which might have changed oxymyoglobin to brown colored metmyoglobin resulting in loss of characteristic color.

For general appearance and acceptability, up to the 3rd day of storage scores were comparable thereafter scores for the same decreased significantly (P<0.05) up to 5th day of storage. The result could be attributed to loss of bloom and appearance of traces of sliminess during the storage period. There was correlated decrease between the sensory parameters during the storage period.

Correlation color changes in indicator with instrumental color evaluation (Lovibond Tintometer color units) of chicken meat

The Lovibond Tinto meter redness (a*) and yellowness (b*) values of chicken meat decreased gradually with increasing storage period. The lowering value of redness, yellowness, hue and chroma positively correlates change in color of the quality indicator during advanced storage period (Table 3). Both redness yellowness value decreased significantly (P<0.05) on 3rd day of storage which was probably due conversion of myoglobin. The results agreed with those of Feldhusen *et al*. (1995) in beef at refrigerated storage and Sahoo and Anjaneyulu (1997) in minced buffalo meat at refrigerated storage for redness and yellowness value consecutively. There was correlated change in sensory color score (Table 3) with instrumental color. The decrease in redness was probably due to formation of metmyoglobin which imparted brownish discoloration to meat.

The hue refers to the purity of color and the chroma refers to the intensity of color (AMSA, 1991), both of which decreased gradually with the storage period in the present study. Both hue and chroma value decreased significantly ($P<0.05$) on the 3rd day of storage. In both of the cases the reason could be attributed to formation of metmyoglobin which increased intensity of brown color. Fading of color further during storage was probably due to conversion of oxymyoglobin to metmyoglobin due to utilisation of oxygen by microbial flora of meat.

CONCLUSION

Crude black mulberry extracts containing anthocyanins, used for development of quality indicator for chicken meat stored at room temperature. During storage of chicken meat the attached indicator changed color with progression of storage period. The response of developed quality indicator found reliable and it was confirmed by the significant correlation with deteriorative changes in quality attributes chicken meat. The developed indicator represents a simple and visual method to detect quality degradation of flesh foods.

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