Summary and Conclusions
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5.1. Effect of pretreatment on physico-chemical characteristics of chicken meat during frozen storage

- Physico-chemical markers chosen to establish the quality of chicken meat with different pre-treatments elucidated the quality profile of the product initially and during storage.
- Out of the three different treatments using Ginger turmeric extract (GTE) (T2, T3 and T4) applied 5% was found to be the optimum (T3) to achieve good textural profile.
- GTE treated samples (T2, T3 and T4) exhibited significant differences ($p \leq 0.05$) in textural profile characteristics in relation to control (T1) and calcium propionate treated samples (T5 and T6).
- The colour profile analysis by establishing hue angle and Chroma values gave a clear picture of treatment on chicken meat.
- Ginger turmeric extract (GTE) gave an increase in chroma values and decrease in hue angles which represents better color characteristics of the product and less discoloration during storage.
- Calcium propionate treated samples (T5 and T6) showed an increase in hue angle and decrease in chroma values, which signifies the decrease in colour intensity of the product.
- Studies revealed the potential of evaluating the water holding capacity (WHC) as a marker to assess the quality profile of raw meat.
- Significant impact on enhancing water holding capacity capacity were observed with GTE treatments (T2, T3 and T4) and decrease in water holding capacity were observed in calcium propionate treatments (T5 and T6) respectively.
- Pretreatment with GTE (T2, T3 and T4) and calcium propionate (T5 and T6) significantly increased ($p \leq 0.05$) the cooking yield in comparison with the untreated sample (T1).
- Ginger Turmeric extracts (GTE) treated samples (T2, T3 and T4) showed a significant variation ($p \leq 0.05$) that is, less percentage of cook loss as compared to calcium propionate treated samples (T5 and T6).
- Studies revealed that the pH values have strong correlation with water holding capacity.
- GTE enhanced the pH values towards the neutrality and calcium propionate decreased the pH towards acidic side, which facilitated its variation in WHC.
- The estimation of moisture content revealed its relation with WHC with respect to treatment.
- Ginger Turmeric Extract (GTE) inhibited the hydrolytic rancidity that is happening in two months of storage in the product.
- Calcium propionate treatment increased the FFA in comparison with control and GTE treated samples.
- Out of the five treatments (T2, T3, T4, T5 and T6), T3 showed excellent characteristics in improvement of physico-chemical parameters of meat during frozen storage.

5.2. Repeated freezing and thawing on physiochemical quality characteristics of chicken and mutton
- Studies established the physico-chemical quality changes occurring during freeze-thaw cycles in two species of meat.
- Significant difference (p≤0.05) in physico-chemical markers were observed between air thawing and water thawing processes.
- pH, WHC, thaw drip, cook loss, texture and colour profile revealed better quality attributed in terms of these markers during different cycles of water thawing.
- Air thawing carried out (T₁c and T₁m) exhibited significant quality alterations in physico-chemical markers compared to cryoprotectant treated (T₂c and T₂m) air thawed samples.
- Effect of 0.5% glucose as cryoprotectants in retaining the quality attributes was clearly established in the study in air thawing and water thawing process.
- Out of the four different samples subjected for freeze-thaw cycles with respect to two species of meat (T₁c, T₂c, T₃c, T₄c for chicken and T₁m, T₂m, T₃m, T₄m for mutton), T₄c and T₄m ie, water thawed samples with cryoprotectants showed excellent quality attributes.
- The trend observed with all physico-chemical markers for assessing quality profile of freeze-thaw cycles did not differ with respect to species.
- SEM studies clearly established positive effect of maintaining the structural integrity of myofibrils with cryoprotectants.
The SEM photographs of two thawing processes revealed that there is a better integrity of muscles in water thaw process compared to air thaw process.

The results obtained for cryoprotectant treatment were in co-ordination with different physico-chemical properties.

Freeze-thaw cycles ie, air thawing and water thawing did not produce any significant changes \((p \geq 0.05)\) in Tg values both in chicken and mutton.

DSC studies with cryoprotectant treated samples showed significant increase \((p \leq 0.05)\) in Tg values which may produce better quality characteristics during storage of the products.

5.3. Moisture adsorption and desorption studies

- Moisture desorption isotherms for a temperature \(25^\circ C\) were obtained for chicken and mutton during four cycles of freezing and thawing. Several models recommended for meats were used to fit the experimental data.
- Moisture sorption isotherms of chicken and mutton during four cycles of freezing and thawing established the equilibrium relationship between the moisture content of foods and the relative water vapour pressure at constant temperatures and pressures
- Out of five empirical models (Oswin, Iglesias and Chirife, Smith, Caurie and Peleg) were tried Peleg model showed best fit.
- The order of model fit were Peleg > Caurie > Smith > Oswin > Iglesias and Chirife
- Sorption isotherms are indispensable to food product and process development, food engineering and industrial quality control

5.4. Factors influencing the determination of glass transition

- The concept of water activity alone is insufficient in predicting shelf stability of frozen food samples. So alternate complimentary concepts like storing meat below glass transition temperature will give a proper insight to the relationship between freezing temperature and shelf stability.
- In our work, the freezing behavior of chicken and mutton samples were studied by employing various annealing temperatures and time. Proper selection of annealing temperature and time is very critical in the determination of Tg.
The present study revealed that an annealing temperature of $-17^0 C$ for 1 hour is best suited for chicken samples during the determination of Tg, as it helps to attain the maximum freeze concentration at reduced time interval. While for mutton, an annealing temperature of $-15^0 C$ for 1 h is enough to attain maximum freeze concentration.

The effect of moisture content as well as the rate of heating on the glass transition temperatures was also determined. A rate of heating $2^0 C$ /min or below is acceptable.

Moisture content has to be estimated correctly before reporting Tg values. Tg values are generally regarded as an indicator of the temperature below which food will be protected from deteriorative reactions. With the help of this study, a proper DSC protocol for determination of Tg of meat samples like chicken and mutton could be recommended.

5.5. Physico-chemical changes in ready to eat pineapple chicken curry during frozen storage

Studies revealed the feasibility of developing RTE shelf stable chicken based flavoursome curry by freezing process.

Incorporation of pineapple for the preparation of product contributed to the textural and sensory properties of products during storage.

The product supplements good quality protein and some moderate source of fat which delivers some of the important fatty acids.

Addition of cryoprotectants did have a significant impact in inhibiting the physico-chemical quality changes like pH, FFA, TBARS and shear force.

The hydrolytic and oxidative rancidity parameters were not significantly different till 6 months of storage at $-18^0 C$.

The product exhibited excellent microbiological safety throughout the storage period.

Total fatty acid profile as established by GLC revealed the presence of saturated fatty acids(SFA), mono unsaturated fatty acids(MUFA) and Poly unsaturated fatty acids (PUFA) in the product.
Unsaturated fatty acids like linolenic acid, linoleic acid and arachidonic acid showed good stability in the product during storage.

Total fatty acid profile as analyzed by GLC revealed a ratio of 1: 0.93: 0.22 for SFA: MUFA: PUFA.

Sensory quality of RTE pineapple chicken curry was rated excellent in terms of color, flavor, consistency, mouth feel, texture and overall acceptability.

The product exhibited good quality attributes in terms of physico-chemical markers and having a shelf life of 6 months at frozen storage.

5.6. Physico-chemical changes in ready to eat mutton curry during frozen storage

Developed RTE mutton curry by optimizing the ingredient combination, processing parameters and freezing.

The product is a RTE shelf stable meat product delivering 12% protein and 8% fat and gives 115 kcal of energy.

The sensory profile of RTE mutton curry was excellent.

Addition of cryoprotectant enhanced the physico-chemical quality attributes of the product during frozen storage.

Hydrolytic and oxidative rancidity parameters did not differ significantly (p≤0.05) during storage of 6 months at -18°C.

The product was microbiologically safe throughout the storage period.

Total fatty acid profile as analyzed by GLC revealed a ratio of 1: 0.82 : 0.29 for SFA: MUFA: PUFA

Unsaturated fatty acids showed good shelf life during storage.