

## Fresh-keeping effect of 3D printed surimi improved by Ca<sup>2+</sup>-nano starch-lutein and its freshness indicator mechanism based on printed anthocyanin

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### [Objective]

Protein-based surimi is suitable for 3D printing to produce customized foods. However, the insufficient bonding ability and weakened function (such as short shelf) become the weak points of 3D printed functional surimi foods. To facilitate its printing effects and fresh-keeping, a surimi added with a combination of Ca<sup>2+</sup> and nano starch-lutein (NS-L) was used. Additionally, though the freshness of some materials changed during storage period, it could not be perceived due to the color of material itself. Hence, it is meaningful to research the printable freshness indicator materials.

### [Methods]

The surimi was added to NS-L and Ca<sup>2+</sup>, printing properties (texture, gel strength, rheological properties) and freshness indexes of the materials were determined. Additionally, printable color-changing material--anthocyanin-hydroxypropyl methyl cellulose-xanthan gum-carrageenan (AHXK) was prepared. Its printing effects and discoloration mechanism (response to pH and ammonia) were determined. Furthermore, the real-time monitoring of freshness on printed surimi was explored.

### [Results]

1. The NS-L and Ca<sup>2+</sup> increased gel strength, hardness,  $\tau$ , viscosity of surimi by 1.2-3 times, forming denser structure and strengthening supporting and bonding ability to enhance printing effects.
2. They also inhibited bacterial growth and spoilage bacteria of printed functional surimi, as well as amino acids decomposition of surimi was decreased by 12%, which limited the ATP decomposition (decreased K) and production of ammonia (decreased TVB-N).
3. The AHX with 5% K had suitable material properties (gel strength, texture, rheology) for printing.
4. The HXK with 0.75% A was sensitive to pH and ammonia, exhibiting significant color-changing on freshness monitoring of printed surimi during refrigeration.

### [Conclusion]

Printed AHXK-functional surimi could achieve the aim of printing effect enhancement, fresh-keeping and freshness monitoring simultaneously, which could promote the application of 3D printing technology on food process.

**Keywords:** Printability; Functional surimi; Preservation; Color-changing; Freshness monitoring