Encapsulated Liquid Smoke flavouring: A safe and natural preservative for food products

Vivek Chauhan[1& 2], Sathish Kumar K[2] and Bindu J[2]

[1]Department of FPT, Kerala University of Fisheries and Ocean Studies, Kochi, 682506

[2]FP Division, ICAR – Central Institute of Fisheries Technology, Cochin, 682029

Corresponding Author: sathishcife@gmail.com

Since ancient times, food preservation has been essential in human culture. Traditional methods like fermentation, drying, salting, and smoking, alongside modern refrigeration and canning, reflect ongoing efforts to extend the shelf life of perishable foods. As concerns over food safety, nutrition, and sustainability grow, focus shifts toward innovative, natural preservation techniques (Ojha & Yadav, 2014). Among these preservative methods, liquid smoke has gained popularity as a natural, safe preservative, providing antioxidant and antibacterial benefits that improve flavour and inhibit microbial growth. However, applying liquid smoke directly can affect taste consistency and stability. Encapsulation offers a groundbreaking solution, allowing controlled release, enhancing shelf life, and safeguarding active components. This article examines encapsulated liquid smoke flavouring as an environmentally friendly, innovative, and effective food preservation method.

Smoking

Smoking significantly enhances various foods and is vital for specialised food products. Besides drying and salting, it is one of the oldest and most primitive preservation methods, dating back to prehistoric times. The primary goals of smoking are to extend shelf life, reduce foodborne illness risk, and add a desirable smoky flavour. Traditional techniques involved heavy curing, which meant heavily salting the food, followed by several weeks of smoking. This process, along with drying and high salt levels, enabled foods to withstand room temperatures for extended periods by drastically lowering water activity (Balachandran, 2001). Smoking meat products has been practised for thousands of years and is among the earliest preservation methods (Djinovic et al., 2008). Traditionally, fish was hung in a kiln over smouldering wood shavings and left overnight to absorb smoke naturally (Adeyeye, 2019). Different methods include cold smoking, hot smoking, mechanical smoking, and liquid smoking, with liquid smoking increasingly recognised as a safe, natural preservative.

Liquid smoke

Liquid smoke is an ingredient that imparts a smoky flavour to foods and can also help extend their shelf life (Dimakopoulou-Papazoglou & Katsanidis, 2017). Compared to traditional smoking, using liquid smoke is quicker, safer, and more environmentally friendly (Arvanitoyannis & Kotsanopoulos, 2012). It is typically produced by burning wood with limited oxygen over time, but rapid pyrolysis can fast-track the process, converting wood into liquid smoke in an inert environment. The main compounds in liquid smoke include organic acids, carbonyls, phenols, furans, and furfurals (Xin et al., 2021). These bioactive substances enhance flavour, colour, antimicrobial, and antioxidant properties in foods (Maga, 2018).

Advantages of LS

- **Enhances texture:** Interacting with proteins, it boosts hardness and gel strength, improving the overall structural quality of products.
- **Prevents fat oxidation:** Phenolic compounds stabilise fats, maintaining flavour and prolonging shelf life.
- **Enhances nutritional value:** Improves the nutritional value with better sensory properties.
- **Consistent quality:** Delivers consistent flavour, aroma, and colour.
- **Extends shelf life:** Its antioxidant and antibacterial properties prevent spoilage and preserve the product for longer.
- **Environmentally friendly alternative:** It minimises the need for direct smoking, reducing the environmental impact while still creating the essential smoky effects.

Disadvantages LS

- The volatile phenolic and carbonyl compounds found in liquid smoke tend to evaporate or break down during processing and storage, resulting in a weaker flavour and a reduced shelf life.
- Applying liquid smoke directly can lead to uneven penetration, which may cause the final product to have inconsistent flavour and aroma, especially in thicker or denser food matrices.
- Some of the active ingredients in liquid smoke are susceptible to oxidation or polymerisation, which can change their sensory qualities and

reduce their antibacterial and antioxidant properties.

- Over time, the phenolic compounds in liquid smoke may decrease the availability of proteins and fats and change how their flavours are released, leading to a less tasty final product.

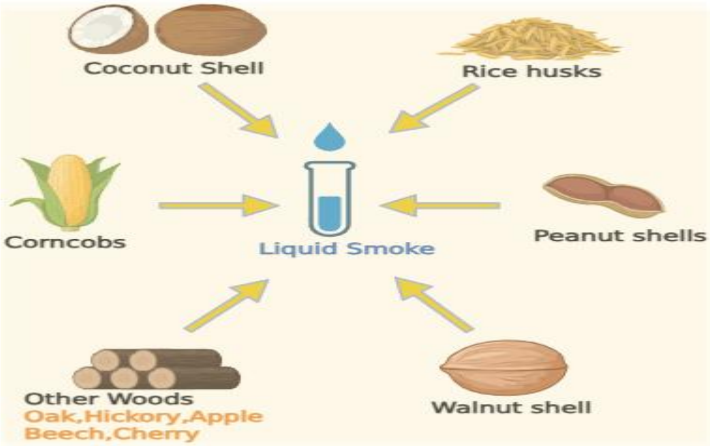

Fig. 1. Raw materials used for LS production

Importance of encapsulation

Encapsulation involves enclosing one substance (the active agent) within another material (the wall). The substance inside, aside from the active agent, can be called the core, fill, active, internal, or payload phase. The surrounding material is often known as the matrix, carrier, shell, coating, membrane, or exterior phase (Fang & Bhandari, 2010). This process has many uses in the food industry, especially for improving the delivery of bioactive compounds like antioxidants, minerals, vitamins, phytosterols, lutein, fatty acids, and lycopene, as well as living cells such as probiotics, into foods.

Materials used for encapsulation

Most materials used for encapsulation in the food industry are biomolecules that need to be food-grade, biodegradable, and capable of forming a protective barrier between the active ingredient and its environment. Among these, polysaccharides are most common, including starch and derivatives like amylose, amylopectin, dextrins, maltodextrins, polydextrose, and syrups, as well as cellulose derivatives. Plant fluids and extracts such as soluble soybean polysaccharides, galactomannans, gum Arabic, gum tragacanth, gum karaya, mesquite gum, and pectin are also used. Marine polysaccharides like carrageenans and alginate, along with microbial and animal polysaccharides like dextran, chitosan, xanthan, and gellan, are frequently employed. Besides polysaccharides, proteins—including caseins, gelatin, whey proteins, and gluten—serve as encapsulating materials. Lipids such as fatty acids, fatty alcohols, waxes (beeswax, carnauba wax, candelilla wax), glycerides, and phospholipids are also suitable for food applications (Nedovic et al., 2011).

How does it get released?

Various techniques are available for encapsulating food ingredients. Since many of these compounds are liquid, drying methods are commonly used. Techniques such as spray drying, spray-bed drying, fluid-bed coating, spray-chilling, spray-cooling, and melt injection serve to encase active ingredients (Nedovic, 2009). During encapsulation, the coating creates a protective barrier around the active component, which is released when this barrier breaks down under certain conditions. For example, in spray and freeze drying, release occurs when heat or moisture interacts with the powder, facilitating diffusion of the active ingredient. In emulsification systems, the flavour is released when emulsion droplets rupture during processing or contact with water or oil. Lipid-based encapsulates from spray-chilling or spray-cooling release their contents when the lipid melts during cooking or processing. In extrusion techniques, such as with alginate beads, the active ingredient is released when the gel structure breaks down during heating, storage, or through diffusion (Nedovic et al., 2011).

Advantages of encapsulation

- Prevents food's active ingredients, such as flavours, vitamins, and antioxidants, from evaporating, reacting chemically, or migrating.
- Preserves product quality by preventing unwanted chemical interactions between liquid smoke components and other food ingredients.
- Enables the precise and controlled release of antibacterial compounds and smoky flavour during the correct heating or processing stage.
- Enhances the nutritional and functional benefits by preserving the antioxidant and antimicrobial properties of liquid smoke while ensuring safety.

Application of Encapsulated Liquid smoke on food products

Liquid smoke is commonly used in different foods to provide a distinctive smoky flavour and assist with preservation. It is extensively employed in processing meats and livestock products, such as processed meats, cheeses, and cheese spreads. Liquid smoke also boosts the flavours of herbs, sauces, soups, canned vegetables, and spice mixes. As Ayudiarti and Sari (2010) note, it is increasingly used in low-fat recipes to give appealing smoky notes without traditional smoking. Various methods exist for curing foods with liquid smoke. The blending method involves mixing 0.1–1% liquid smoke by weight directly into items such as cheese, grilled meats, salami, sausages, emulsified meats, and condiments (Budaraga, 2014). Dyeing is another technique, where products like fish, pork, sausage, shoulder cuts, and cheese are soaked in a liquid smoke solution for 50-60 seconds to allow flavour and colour to develop (Budaraga, 2014). Injection involves directly inserting a 0.25-1% smoke solution into foods like fish to ensure even distribution of flavour (Girrard, 1992). Atomisation sprays liquid smoke into a chamber where products like sausages, ham, and meat alternatives pass through, ensuring even coating and absorption (Girrard, 1992; Hollenbeck, 1978). Evaporation heats liquid smoke to produce smoke vapour that contacts the food directly, making it suitable for daily use (Hollenbeck, 1978). These methods provide diverse options for adding smoky flavour to fish and other foods without using traditional smoking techniques.

Research into encapsulated liquid smoke, particularly in nano- or microencapsulated forms, is expanding to enhance the stability and functionality of smoke flavourings in foods. Nanoencapsulation transforms liquid smoke into nano-sized powder via techniques like spray drying, which improves storage stability and protects bioactive compounds such as phenols, antioxidants, and volatile substances. This encapsulation preserves the antibacterial and antioxidant qualities of liquid smoke, making it ideal for high-protein foods. It has been successfully tested as an antibacterial agent in the cold storage of white snapper fillets. Encapsulation materials like maltodextrin, arabic gum, and their combinations help produce stable micro- and nanocapsules. These encapsulated flavours maintain sensory qualities, extend shelf life, reduce oxidation, and release smoky flavours and beneficial compounds gradually. Using encapsulated smoke flavours ensures uniform flavour distribution, protects against environmental factors, and allows the addition of smoke flavour in cases where applying liquid smoke directly is impractical.

Future perspective

As an advanced preservative, encapsulated liquid smoke flavouring holds significant promise and aligns well with the global shift towards natural, clean-label, and sustainable food solutions. Future advances in encapsulation techniques, such as biodegradable encapsulation and nanoencapsulation, will improve their stability, effectiveness, and controlled release across various food systems. Incorporating encapsulated liquid smoke flavourings into processed, versatile, and functional foods could transform preservation methods as the food industry moves away from artificial additives. This technology has the potential to enhance food safety, extend shelf life, and improve flavour profiles without compromising environmental or health standards.

References

Adeyeye, S. A. O. (2019). Smoking of fish: a critical review. *Journal of Culinary Science & Technology*, *17*(6), 559-575.

Arvanitoyannis, I. S., & Kotsanopoulos, K. V. (2012). Smoking of fish and seafood: history, methods and effects on physical, nutritional and microbiological properties. *Food and bioprocess technology*, *5*(3), 831-853.

Ayudiarti, D. L., & Sari, R. N. (2010). Liquid smoke and its applications for fisheries products. *Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology*, *5*(3), 101-108.

Balachandran, K. K. (2001). *Post-harvest technology of fish and fish products*. Daya Books.

Budaraga, I. K. (2014). Utilization Using Liquid Smoke Fish Fillet As Preservatives.

de Vos, P., Faas, M. M., Spasojevic, M., & Sikkema, J. (2010). Encapsulation for preservation of functionality and targeted delivery of bioactive food components. *International dairy journal*, *20*(4), 292-302.

Dimakopoulou-Papazoglou, D., & Katsanidis, E. (2017). Effect of maltodextrin, sodium chloride, and liquid smoke on the mass transfer kinetics and storage stability of osmotically dehydrated beef meat. *Food and Bioprocess Technology*, *10*(11), 2034-2045.

Djinovic, J., Popovic, A., & Jira, W. (2008). Polycyclic aromatic hydrocarbons (PAHs) in different types of smoked meat products from Serbia. *Meat Science*, *80*(2), 449-456.

F. Gibbs, Selim Kermasha, Inteaz Alli, Catherine N. Mulligan, B. (1999). Encapsulation in the food industry: a review. *International journal of food sciences and nutrition*, *50*(3), 213-224.

Fang, Z., & Bhandari, B. (2010). Encapsulation of polyphenols–a review. *Trends in food science & technology*, *21*(10), 510-523.

Girrard, J. P. (1992). Smoking in the Technology of Meat Products. Clermont-Ferrand. *Ellis Horwood, New York pp*, *165*, 205.

Hollenbeck, C. M. (1978). Summaries of Aldition Paper on Smoke Curing. In *The Symposium Smoke Curing-Advences in Theory of Food Tech. Dallas. Tex June* (pp. 4-7).

Maga, J. A. (2018). *Smoke in food processing*. CRC press.

Nedovic, V., Kalusevic, A., Manojlovic, V., Levic, S., & Bugarski, B. (2011). An overview of encapsulation technologies for food applications. *Procedia food science*, *1*, 1806-1815.

Ojha, K., & Yadav, A. (2024). Preservation innovation: Modern methods and techniques redefining food longevity. *Res. Gate*, *1*(1), 98-99.

Perez-Rodriguez, M. L., Garcia-Mata, M., & Bosch-Bosch, N. (1998). Effect of adding smoke-flavouring to frankfurters on nitrite and nitrate levels. *Food chemistry*, *62*(2), 201-205.

Pszczola, D. E. (1995). Tour highlights production and uses of smoke-based Flavours. *Food technology (Chicago)*, *49*(1), 70-74.

Šimko, P. (2002). Determination of polycyclic aromatic hydrocarbons in smoked meat products and smoke flavouring food additives. *Journal of chromatography B*, *770*(1-2), 3-18.

Šimko, P. (2005). Factors affecting elimination of polycyclic aromatic hydrocarbons from smoked meat foods and liquid smoke Flavourings. *Molecular nutrition & food research*, *49*(7), 637-647.

Simon, R., de la Calle, B., Palme, S., Meier, D., & Anklam, E. (2005). Composition and analysis of liquid smoke flavouring primary products. *Journal of Separation Science*, *28*(9-10), 871–882.

Wandrey, C., Bartkowiak, A., & Harding, S. E. (2009). Materials for encapsulation. In *Encapsulation technologies for active food ingredients and food processing* (pp. 31-100). New York, NY: Springer New York.

Xin, X., Dell, K., Udugama, I. A., Young, B. R., & Baroutian, S. (2021). Transforming biomass pyrolysis technologies to produce liquid smoke food flavouring. *Journal of Cleaner Production*, *294*, 125368.

* * * * * * * * *