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Sensors in Food Industry : A Review

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Abstract: *This paper includes study and overall review of diverse sensors applied in the food industry for various purposes. It includes various findings and relevant data about how effective each sensor is and their future advances. Biosensors play a major role in the food industry as compared to other sensors .Food processing industry faces numerous challenges from safety to food quality. The analytical techniques for quality and safety Monitoring is too slow, time consuming it can cause food poisoning , we can't fully rely on them.. Hence we have to develop fast-working and trustworthy techniques for safety , quality and monitoring of food products. This can be done by using the sensor techniques in the food processing industries.[01].*

Keywords: Biosensor, E-tongue, E-nose, Proximity, Ultrasound

Methodology of reviews: This paper is written after receiving various research papers from elsevier , science direct , research gate and some government sites with keywords like sensors , food industry , biosensors ,etc . It is drafted in a way which includes every important detail of the topic and data and images from studying the papers and then understanding and applying them in this paper

I. INTRODUCTION

Currently in the industries, maximum processes are based on monitoring systems to check product quality and proper procedure. To obtain accurate and reliable results depends on selection and application of the appropriate sensor technology. To obtain it, sensors must be durable, flexible, and reliable .We need to have appropriate sensor selections to understand its properties and working for a particular field. They are important for monitoring and control systems in the food industry. They are dependent on all internal and external responses from the environment. There is an ardent need for detection of different components of foods and beverages along with the food borne and waterborne pathogens, toxins with high specifications.
We have different sensors like Biosensensors, nanobiosensors, e-nose, e-tongue, proximity, ultrasound sensors which help us in various ways in the food industry .[01]

Biosensors

Food borne illness has a life-threatening danger towards the public and as a result an estimated loss of $30 billion USD per year. Techniques like Polymerase Chain Reaction (PCR) , ELISA require a lot of time to collect samples and analyse while biosensors do rapid detection.Using Biosensors in the food industry will overcome this issue .[08]

Food Biosensors

Biosensors have wide application in detecting enzymes, which is mainly used in the alcohol and beverages industry for detecting carbohydrates, amino acids, amines, amides, phenol etc. The table below lists the food component and the enzymes sensed by the biosensors to measure or detect the specified components.

FOOD COMPONENTS	ENZYME USED
Glucose	Glucose Oxidase
Fructose	Fructose-5-hydrogenase

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Sucrose	Glucose oxidase, Mutarotase, Invertase
Lactose	GalactoseOxidase,Peroxidase
Glutamate	Glutamate Oxidase
Malate	Malate dehydrogenase,Diaphorase
Glycerol	Glycerol Dehydrogenase
Cholesterol	Cholesterol Oxidase
Essential fatty acids	Lipoxygenase
Ethanol	Alcohol Dehydrogenase
Choline	Choline Oxidase

Table 1: Enzymes sensed by food biosensors [03]

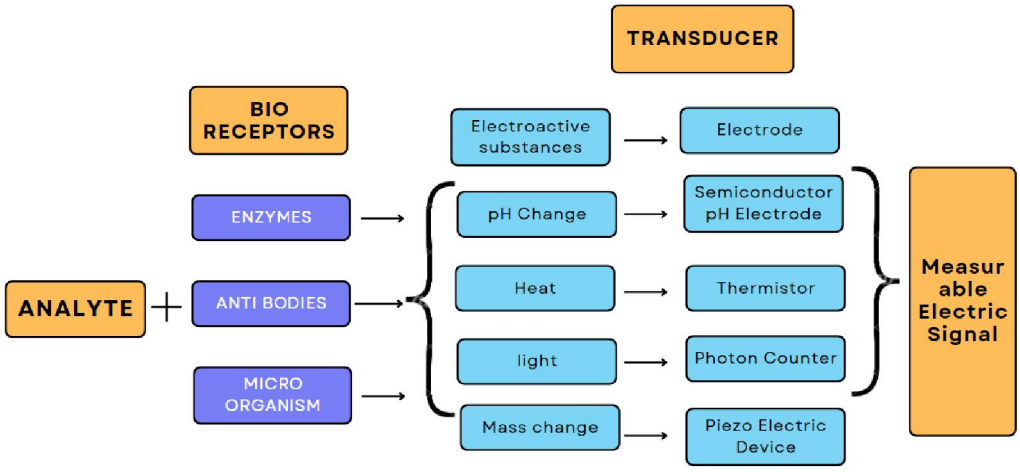

Figure 1: Principle of operation of food biosensors [03]

Various studies on Biosensors application in food:

Media/ food	**Detection/ determination**	**Ref.**
Meat	Glucose gradient	(Maines, 1996)
Fish	Determination of K-value Determination of Trimethylamine	(Mitsubayashi., 2004)
Milk	Presence of urea determination of lactose concentration	(Meshram, 2018)
Wine	Determination of sulphur dioxide Mycotoxins detection Heavy metals detection Detection of tastants and suppression of sourness	(Meshram, 2018) (Hosnedlova, 2019) (Odobašić et al, 2019) (CamaraMartos 2016)

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	by the sweetness Determination of histamine Separation of yeast cells in sparkling	(RiulJ_unior, 2003) (Berovic, 2014)
Fresh fruits and vegetable	Fruit acids Concentration of total soluble solids Total titratable acidity	(Meshram, 2018)
Fruit juices	Determination of ascorbic acid	(Meshram, 2018)
Tea	Detection of polyphenols	(Forzato et al, 2020)

Table 2: Various studies on biosensors application in food [06]

Biosensors for Food-Allergen Detection: People often suffer from food allergies and the majority are lactose intolerant. An electrochemical immunological sensor was developed for β-lactoglobulin, an allergen which is present in milk . The sensor is made on a modified layer of graphite which is a screen-printed electrode with no mobility of β-lactoglobulin antibodies. The sensor was used to screen various food items made out of milk ,flour , bakery items snacks,etc, and the outcomes were compared with the ELISA assay. [01]

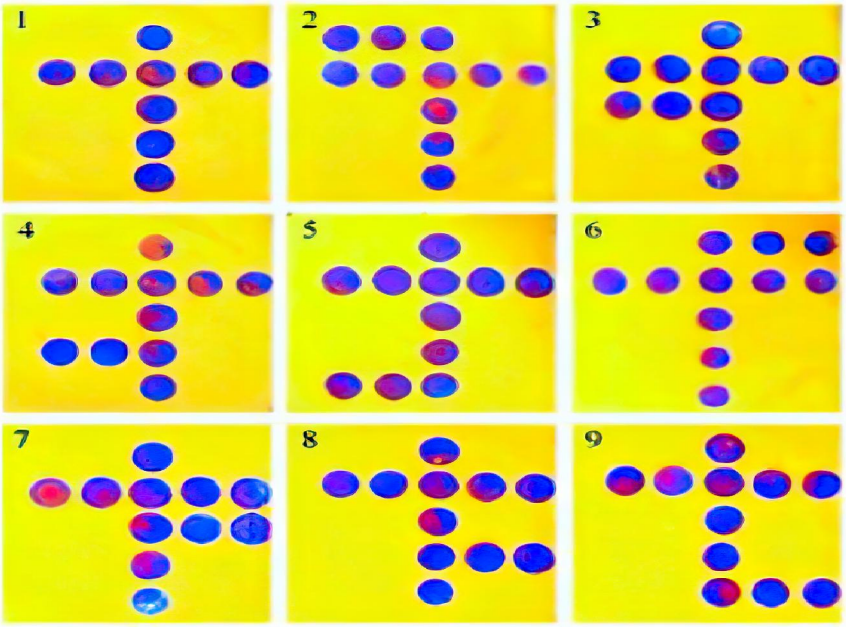

Figure 2: Allergen-detection chip [08]

Adding false materials in food that is adulterating it is a huge problem which should be solved with proper analysis. A hazardous health issue is adulterating milk products with melamine due to its characteristic to increase the protein content. This has resulted in about 300,000 sick children and 06 deaths [01]. An antibody-based optical biosensor was developed for the same .[01].

In the current situation , most of the food biosensors still need testing before implementing on foods.

Table 3 :Nanobiosensors in food industry [05]

Nanobiosensor	**Nanomaterial used**	**Sensor type**	**Applications in food industry**	**Limit of detection**	**Reference**
Magnetic particle chains	Antibody	Sandwich ELISA	Detection of Salmonella in chicken	11 CFU/ml, 2.5h	Zheng et al.(2020)
Carbon nanowires	DNA aptamer	ELISA	Detection of	80 CFU/ml,	Qiu et

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			Salmonella in chicken	2h	al.(2019)
Silver nanoparticles	Urease-antibody	ELISA	Detection of Salmonella in food samples	100 CFU/ml,2h	Wang et al.(2020)
Iron oxide nanoparticles	Antibody	ELISA	Detection of Salmonella in milk	34 CFU/ml	Chen et al.(2019)
Sandwich nanoparticles with catalase enzyme	Antibody	ELISA	Detection of Salmonella in chicken	35 CFU/ml, 3h	Guo et al.(2020)
Zinc Oxide	Antibody	Sandwich ELISA	Salmonella typhimurium	1.5h	Huang et al.(2020)

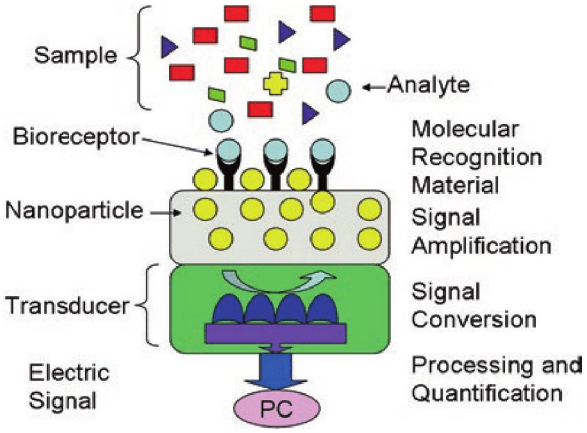

Figure 3 : Components of Nanobiosensor [10]

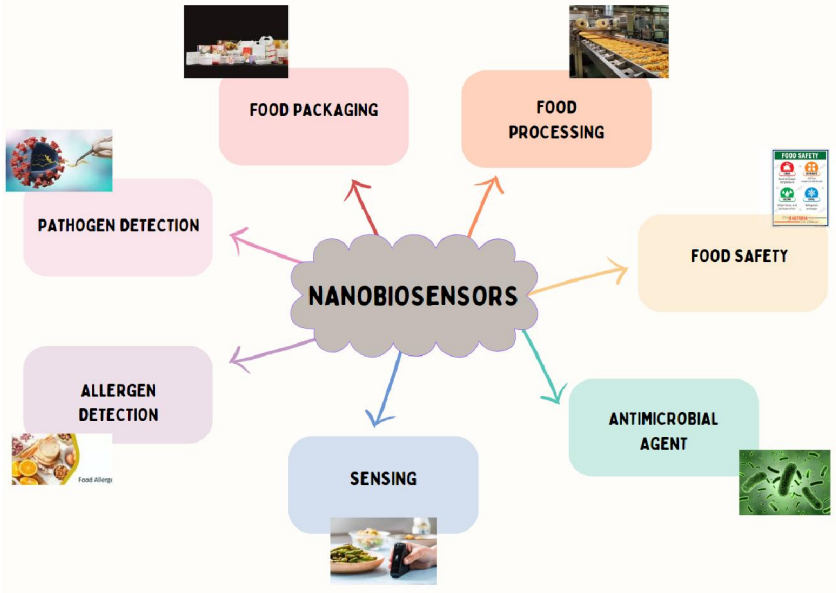

Figure 4: Applications of nano biosensor in the food industry [05]

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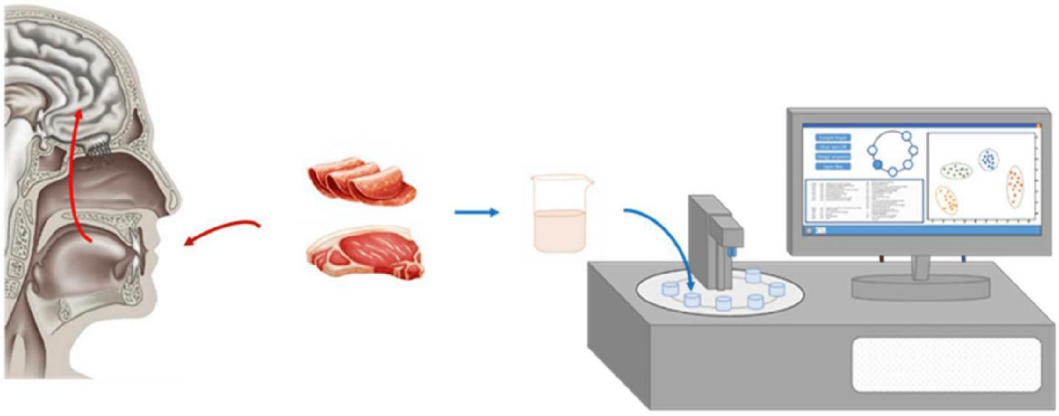
Electronic nose :

It is a recent most used sensor which detects odour and vapours and does further analysis . It's widely used to detect crops with diseases, freshness or spoilage of fruits and vegetables during processing and packaging . It is used to detect foul or harmful chemical reactions through smell based on various mechanisms .It can detect poisoned and harmful odour that our nose cannot identify. These sensors are very commonly used in growing crops, manufacturing food products,etc. [01]

There are five way to detect aromatic component in food :

1. An aroma releasing system
2. A chamber where sensors are built.
3. An electronic transistor that converts chemical signal to electrical signal, amplifies and conditions it.
4. A digital converter (transformation of the electrical signal to digital)
5. A computer microprocessor.



A [Human Tongue] B[Electronic Tongue]

Output	←Brain	←Taste Bulbs	← Taste Receptors

Sensor—> Array	Signal —> Transducer	Data —> Analysis	Output

Figure 5. Electronic Nose Concept [04]

For example, to determine freshness of fish the main indicator is hypoxanthine colorimetric freshness sensor was developed.

$$\text{Hypoxanthine} + O_2 \xrightarrow{\text{XOD}} \text{Xanthine} + H_2O_2$$

$$\text{Xanthine} + O_2 \xrightarrow{\text{XOD}} \text{Uric Acid} + H_2O_2$$

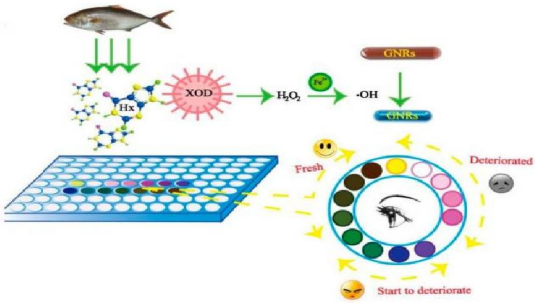


Figure 6: Freshness sensor for fish via hypoxanthine detection [01]

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E-tongue taste sensors: It artificially senses sourness, bitter, salty, and umami flavour. E-tongue sensors are used for both qualitative and quantitative analysis. It can also be used for environment monitoring.[01]

Intelligent sensors play a crucial role in enhancing sustainability within the food and drink manufacturing industry. Here's a breakdown of their contributions in a point-wise manner:

- Data Monitoring and Collection
- Process Optimization
- Quality Control
- Energy Efficiency
- Water Management
- Waste Reduction
- Supply Chain Visibility
- Traceability
- Predictive Maintenance
- Compliance and Reporting
- Smart Packaging
- Real-Time Analytics

Proximity Sensors

In the food market application, proximity sensors are used for packaging inspection. They can detect any defects or anomalies in the packaging such as broken seals or leaks. Additionally, proximity sensors can be used for counting the number of packaged food items in order to ensure accuracy in inventory management. Proximity sensors are generally used to detect any foreign substances that may enter the food processing & packaging areas.

Ultrasonic sensors in food industry

Ultrasound is a new budding sustainable technology which increases the rate of change of various procedures in the food industry. Its application is in temperature and pressure to implement a combined effect, which increases its efficiency[09].

[1] **The low intensity or high-frequency ultrasound waves sensors**: - These waves can be utilised to evaluate the structure of the food product, to determine its elements such as meat, eggs and fishes.

[2] **The high intensity and low-frequency ultrasound waves sensors:-** They disrupt the internal and external attributes of the food products .It has enormous use in emulsification, defoaming, regulation of microstructure.[09]

II. CONCLUSION

According to the basic needs of the food industry and the growing demands these sensors should be considered as saving time and giving quality which will save millions of lives is what matters and should be considered important. Sensors play a significant role in the detection and identification of contaminants during the food manufacturing processes and it increases the food quality, safety, production and profitability in the food processing industries.

The effective application of sensor technology is and will continue to be a significant factor in the competitiveness of the food industry.

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