ICEST_BT_004

FOOD SPOILAGE DETECTION USING CURCUMIN IMPREGNATED SMART BUTTONS

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Abstract:

Food spoilage is a major concern in the industry, affecting both consumers and producers. Our research proposes a reliable and efficient solution to identify food spoilage such as fish using portable sensor buttons impregnated with natural turmeric. Active ingredient curcumin isolated from Rhizomes of Curcumin longa is known to change color from yellow to deep red on changing the pH from acidic to basic. pH of most of the freshly caught seafood products such as Indian anchovy (*Stolephorus indicus*) is around neutral (pH 7), and during pre-rigor stage pH of the meat turns slightly acidic side (~pH 6.5) which takes around 3-5 hours , and during post rigor stages enzymatic degradation produces volatile bases that in turn changes the pH to alkaline side (~7.5-8). Hence pH shift in meat from acidic to alkaline is the indicator of spoilage, which also implies that the meat is more than 3-5 h of post-harvest storage. Hence, curcumin impregnated smart button is a potable, food grade, and affordable food spoilage indicator. This technology can also be extended to various other food products by using bioactive compounds from various other plant sources that are active at different pH ranges. There is a great scope of this product while procuring food products.

Key Words: Curcumin, Indian anchovy, Smart button, Food industry, Sensors.

1. Introduction

Throughout human history, natural plant products have been employed for a variety of reasons. Many of the plants from which these natural compounds are generated are billions of

ISBN-978-81-19905-39-3

years old, having co-evolved with animal life called a natural defence against illness and infection, higher plants manufacture tens of thousands of these compounds called secondary metabolites. Many of these natural compounds contain pharmacological or biological properties that can be used in the development of pharmaceutical drugs. Plant-based medicines have been essential to the health care of many societies, both ancient and modern. The usage of the turmeric plant for medical purposes dates back over 4000 years. Turmeric is utilised in Southeast Asia both as a primary spice and as a part of religious rituals. Turmeric, which is a vivid yellow colour, is also referred to as "Indian saffron" because of this. The more than 3000 publications on turmeric that have been published in the last 25 years show that modern medicine has started to understand its significance. The safety and effectiveness of turmeric are further discussed after discussing in vitro research, animal studies, and ultimately studies conducted on humans[1].

Although it is grown in tropical and subtropical areas worldwide, turmeric is mostly grown in India, Thailand, Taiwan, and other Southeast Asian nations. Tropical regions are the best places to cultivate turmeric since it thrives in warm, humid climates and grows at heights between 400 and 1,000 m above sea level. After planting, the plant needs 6 to 8 months to grow in semi-shade, under trees, on clayey, well-drained soils, and before it can be harvested. The turmeric rhizome can be collected once the leaves have dried. After that, rhizomes are dried, boiled, and then pulverised (into a powder) to prepare them for export[2].

There is an expanding body of study pertaining to the medicinal use of turmeric, which is a well-known culinary spice and herbal treatment. It is unclear which turmeric preparations are best for particular conditions, though. This study sought to inform practitioners and academics on the use of turmeric as a therapeutic alternative by conducting a meta-review of systematic reviews. Over 50 different types of diarylpentanoids and diarylheptanoids, collectively known as curcuminoids, are found in turmeric. Of these, "curcumin," which is a variable mixture of the non-volatile diarylheptanoids diferuloylmethane (curcumin I), desmethoxycurcumin (curcumin II), and bisdesmethoxycurcumin (curcumin III), is the most thoroughly researched. Flavonoids and an essential oil with sesquiterpene ketones such turmerones, curlone, and zingiberene are additional components. Although the low bioavailability of curcuminoid extracts means that activity within the gut may become potentially more significant or that systems need to be developed to improve curcumin delivery to target tissues, it is believed that curcuminoids and essential oils are

ISBN-978-81-19905-39-3

responsible for the biological effects. There are many different products on the market with widely varying formulations as a result of efforts to increase the bioavailability, including liposomal formulations, nano-micellar formulations, and the use of other botanical ingredients like piperine from black pepper. This makes it challenging to identify which compounds or combinations of compounds are having an effect[3].

The primary plant component of turmeric that is employed in food preparation and other pharmaceutical applications are its rhizomes (roots). Because of their volatile components, the plant's leaves and flowers are also being used more and more frequently in fragrance applications and medical research. The current chapter covers a general introduction to turmeric as well as its medicinal and cultural significance. There is a brief discussion on the turmeric's agricultural aspects. The chapter also provides specifics on the chemistry and processing procedures used to separate the essential oil and active ingredients. Additionally, the curcumin, the primary curcuminoid found in turmeric, has been highlighted in a summary of the synthetic procedures for curcuminoids documented thus far[4].

Curcumin, a yellow pigment found in the Indian spice turmeric has been linked to the suppression of neuropathic pain, angiogenesis, tumorigenesis, diabetes, diseases of the liver, skin, and cardiovascular, respiratory, and nervous systems(Fig 1). It has also been linked to the suppression of inflammation. Curcumin's colour, lack of water solubility, and relatively low in vivo bioavailability limit its usefulness. There is a vigorous hunt for the "super curcumin" due to the numerous medicinal effects linked to curcumin. In the current study, turmeric natural dye was tested for its antimicrobial properties against several bacterial strains. The antibacterial activity of turmeric extract against ten different bacterial strains was proven in the current study using in vitro tests[5].

2. Experimental Procedure

MATERIALS

In 2023, this project's work will be completed. The project's goal is to create a food sensor that can detect rotting using turmeric.

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2.1. Chemicals and reagents:

It uses HCl and NaOH.

2.2 Rhizome of turmeric:

At latitude 13.21505 and longitude 75.05525, communities close to the undivided Dakshina Kannada District were used to harvest turmeric horn. The turmeric horn was washed under running water to eliminate dirt particles, dried in the sun for two days, and then ground.

Fig.1: Turmeric powder

2.3 Extractor of soxhlets:

A piece of lab equipment called the Soxhlet extractor was created in 1879 by Franz von Soxhlet.The turmeric horn's curcumin is extracted using it.

Fig.2: Extraction of Curcumin from rhizomes of turmeric

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2.4. Spectrophotometer:

Curcumin longa's absorbance and transmission are measured using this technique.

Fig.3: UV Spectrophotometer

2.5. Cotton fabric:

For absorption, it is employed. A dye's transfer from an aqueous solution to a cloth surface is called absorption.

Fig. 4: Cotton Fabric

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2.6. pH scale:

To gauge various liquids' acidity and alkalinity levels.

Fig.5: pH scale

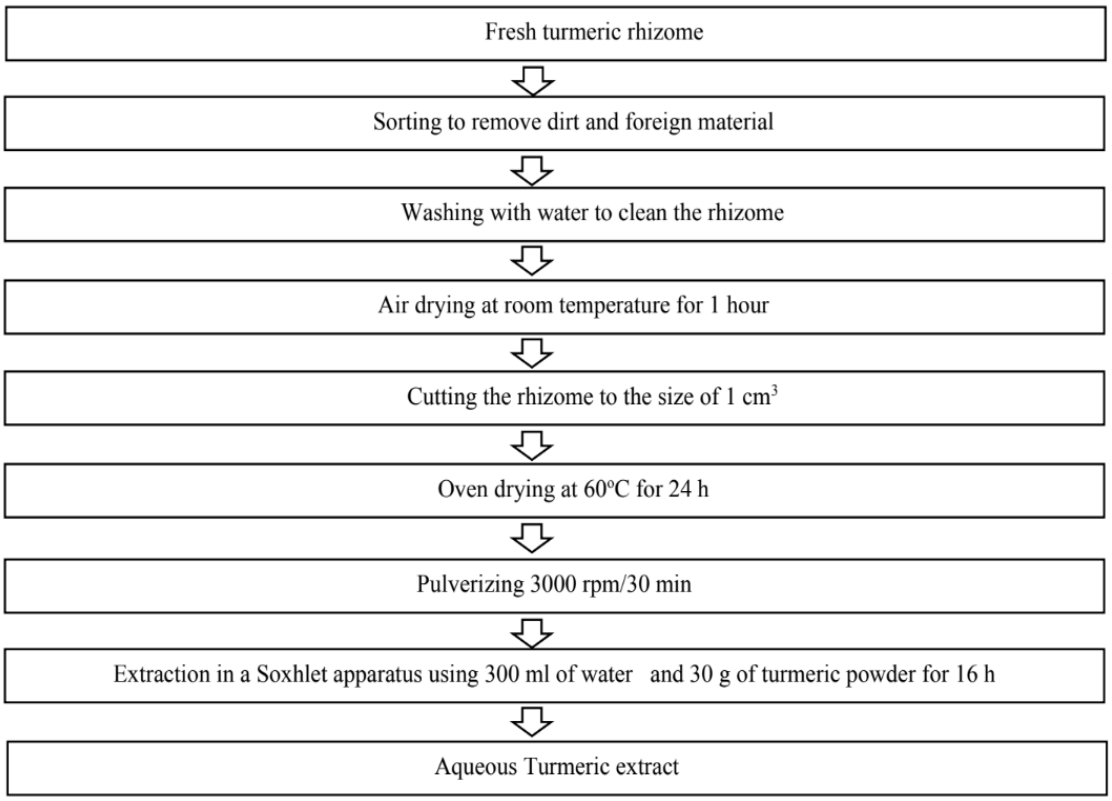

Fig. 6: Process of extraction of Curcumin from Curcumin longa

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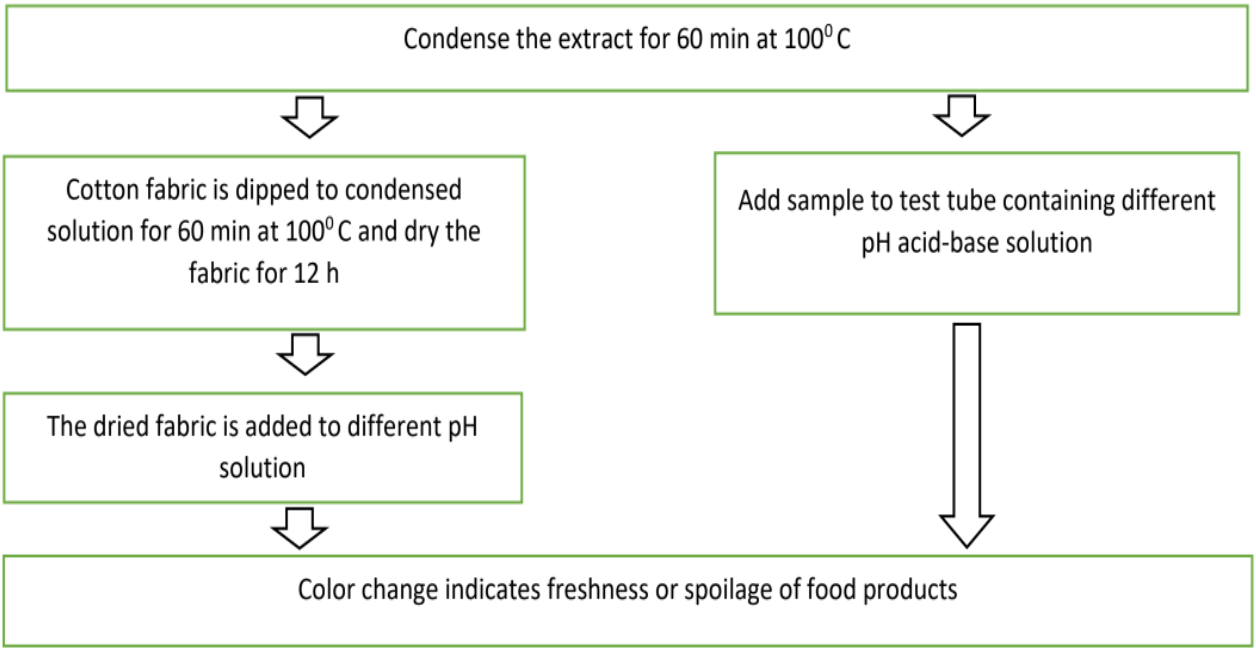

Fig.7: Dying process

Turmeric rhizomes were dried in an oven at 105 °C for three hours. To create a homogenous powder with a particle size of 0.18 mm, dried rhizomes were triturated in a mortar and then screened through a sieve with mesh size 80 [6]. In order to prevent moisture absorption, the turmeric powder was kept in the refrigerator [7-8]. The reference procedure, the Soxhlet extraction, was carried out as follows: A thimble containing 15 g of ground turmeric powder was weighed, implanted in the Soxhlet device, and filled with acetone as the extraction solvent progressively [9]. Within 8 h, the extraction experiment was completed at 60°C. Using a rotary evaporator and a vacuum at 35°C, the acetone was separated from the extract once the extraction was finished. To determine the curcumin content using HPLC, the residue was first dissolved in 10 mL of methanol after being dried and weighed. Because of its strong solubilization capacity, acetone was utilised as the extraction solvent in all extraction tests [10].

For pH values of 4, 8, and 9, (fig.8) the colour of the solutions and a change in wavelength 383, 385, and 404 nm, respectively, were observed [11]. The reported statistics are consistent with the literature, which states that Curcumin solutions change colour from yellow to brownish

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orange at pH levels between 2 and 13. The keto-enol tautomerism explains this: in neutral and inacidic environments, Curcumin is primarily in the ketoform whereas in alkaline media, it confirms an enol (colour degradation: brownish orange).

Fig.8: Color change in different pH solutions

Additionally, the breakdown of curcumin in an alkaline pH environment may result in derivative products like feruloyl methane, which quickly forms a brown condensation product and shifts the absorption peak from 420 nm at pH 2–10 to 460 nm at pH 12–13. Based on the findings of this study, the PEG600-Curcumin conjugate solutions exhibit no condensation product throughout the whole pH range, indicating good solubility in aqueous solutions and enhanced pH stability.

Since in aqueous solutions was insufficient to characterize Curcumin, solutions of Curcumin and PEG600-Curcumin in acetone a suitable solvent for both forms were also studied. The collected spectra revealed that Curcumin has a shoulder at 445 nm and a maximum wavelength at 420 nm. The finished product exhibits a hypsochromic shift of around 20 nm; the arm's maximum absorption occurs at 425 nm, indicating the presence of a conjugated structure that has been broken.

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3. Results and Discussions

Turmerin has demonstrated to be a highly accurate and sensitive indicator of food decomposition in a variety of food products. Testing in comparison to other detection techniques revealed that turmerin was more reasonably priced, environmentally friendly, and user-friendly. To evaluate turmerin's capabilities as a natural preservative and to optimise its use in various goods, more study is required [12].

Because curcuminumin can increase the shelf life of food and serve as a quality indicator, several scientists have recently begun researching its functional characteristics and pH-dependent colour change properties for usage in food packaging. Curcuminumin is primarily emphasised in this review article as a natural food colourant used in active and intelligent packaging applications. The main facts about curcuminumin and its biological characteristics are first briefly discussed. The use of curcuminumin with various types of polymers as well as various preparation methods is then covered in detail. Curcuminumin's use in active and smart packaging applications has also been extensively covered. The commercial potential of curcuminumin in food packaging as well as the potential for further study were described in the final section. We are aware of just one review article that has been written and published on this subject. Therefore, this thorough analysis summarises the effects of curcuminumin on the functional and physicochemical qualities of various polymer-based active and intelligent food packaging films and offers the most recent prospects and trends for employing packaging films with curcuminumin added. The colour of the solution went from bright yellow to reddish-brown as the pH level rise. From pH 1 to pH 8, there were no discernible colour changes (Table 1) [13].

At pH 9, the colour started to shift from brilliant yellow to bright brown, but it didn't turn reddish-brown until pH 10, and it didn't turn wine red until pH 12 and above. This is because fully deprotonated curcuminumin appears red at pH 10 and above, where the absorption maximum is at 467 nm, and curcuminumin's breakdown is pH-dependent and suffers rapid degradation at higher pH levels [14].

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Table.1: pH data of turmeric

pH	Absorbance	Transmission
1	2.50	0.270
2	3.00	0.900
3	3.00	0.060
4	3.00	0.160
5	3.00	0.060
6	3.00	0.130
7	3.00	0.190
8	3.00	0.070
9	3.00	0.030
10	3.00	0.090
11	3.00	0.030
12	3.00	0.060
13	3.00	0.090
14	3.00	0.140

Additionally, second-order kinetics are used to break down curcuminumin in methanol and aqueous systems, with the help of buffers such phosphates at pH levels 6 through 9 or carbonates at pH levels 9 to 10. According to these investigations, curcuminumin's degradative processes progressed more quickly at higher pH values than they did at lower pH levels (fig.9). Since curcuminumin is pH sensitive and depends on pH, it cannot be dissolved in neutral or acidic environments. The chemical breakdown of curcuminumin is very unstable near physiological pH levels.

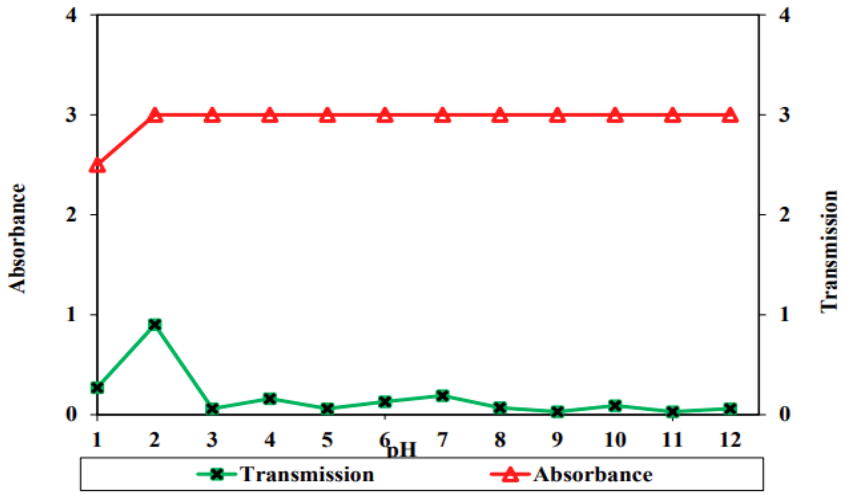

Fig. 9: Change in absorbance and transmission of the turmeric Extract at different pH

ISBN-978-81-19905-39-3

The initial absorbance values of the alkaline curcuminumin solutions were marginally greater than those of the acid curcuminumin solutions, exhibit keto-enol tautomerism, having a dominating keto form in acidic and neutral conditions and an enol form in the medium alkali state. Contrarily, curcuminumin is soluble in an alkaline environment and as a result, profound curcuminumin deprotonating in an alkaline environment led to the production of a peak at 568 nm (fig.10).

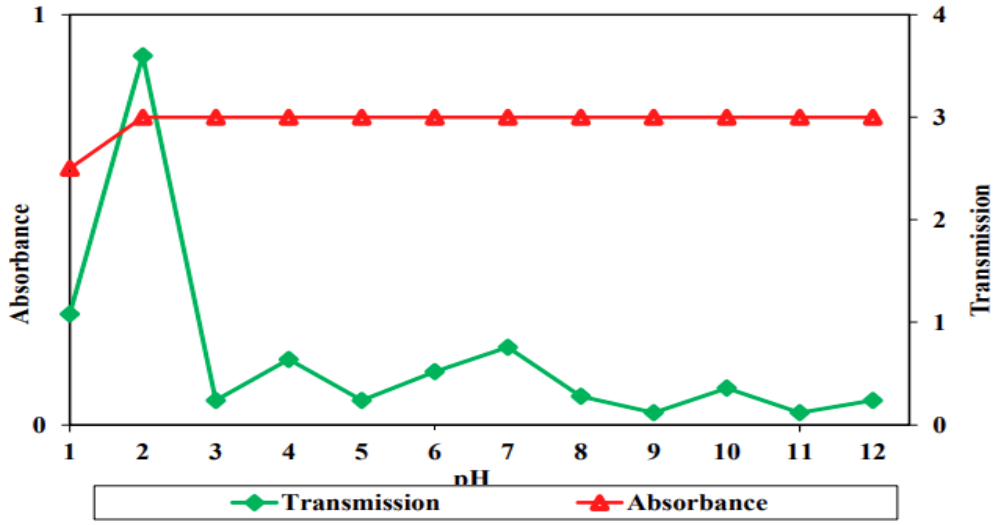

Fig.10: Change in absorbance and transmission of the turmeric extract impregnated cotton fabric at different pH

A maximum absorption peak at 433 nm was visible in the solution at neutral and acidic conditions. When curcuminumin reacted with an alkaline solution of HX, the peak, however, migrated to the right, resulting in a peak value of maximum absorption at 568 nm. The curcuminumin solution was initially yellow, but when the pH level was 9, it turned oranges red. Based on the amount of curcuminumin in each film, colour analysis shows how the colors of films alter. The whitish index denotes the union of yellow-blue and brightness into a single phrase. Lower WI values revealed darker, less transparent, and luminescent films. A higher curcuminumin concentration resulted in more pigmented films due to the polymeric interaction of curcuminumin, while E served as an index of the overall colour changes experienced by the CRRS films, demonstrating a substantial difference (fig.11).

ISBN-978-81-19905-39-3

Fig.11: Indian anchovy *(Stolephorus indicus)*

Conclusion

Lack of understanding about food quality and preservation methods results in food. Chemical freshness indicator colours and preservatives are not biodegradable. Our sustainable food sensor with antibacterial and antioxidant property reflects the freshness of the food product through color change and as a potential scope in a replacing unsustainable sensor. Natural plant-based colors exhibit change in color with pH change and also have antimicrobial and antioxidant properties.

ISBN-978-81-19905-39-3

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