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DETECTION OF BORAX IN MEATBALL SNACKS USING CURCUMIN STICKS

Darmawati[*1], Safridha Kemala Putri[2], Rahmayanti[3], Siti Hadijah[4]
[1,2,3,4]Poltekkes Kemenkes Aceh
Indonesia

***** Corresponding email: *darmawati0304@gmail.com*

ABSTRACT

Borax is a food additive that is prohibited for use according to Indonesian Ministry of Health Regulation No. 033 of 2012. Food additives are only permitted if they do not damage the nutritional content of the food and do not contain harmful substances. Despite its prohibition, borax is still sometimes used as a preservative in foods such as meatballs to improve texture and shelf life. Borax can be identified using curcumin compounds derived from turmeric.This study aims to evaluate the effectiveness of curcumin compounds in curcumin sticks made from natural turmeric, tested at different time intervals of 1 minute, 5 minutes, and 10 minutes. The method used is an instrumental method with a laboratory approach, testing curcumin sticks on artificially prepared meatballs containing borax concentrations of 0.1%, 0.5%, and 1%. The results showed that curcumin sticks were able to detect 0.5% borax at 5 and 10 minutes, and 1% borax at 1, 5, and 10 minutes. It can be concluded that the higher the borax concentration, the faster the curcumin stick is able to detect it.

Keywords*: Food additives, Borax, Turmeric, Curcumin, Curcumin stick*

INTRODUCTION

Food is a fundamental necessity required by living beings to sustain life. Good-quality food must contain essential nutrients such as carbohydrates, proteins, fats, vitamins, minerals, and water. In addition, it must be free from harmful substances that may pose health risks, making it important to ensure food safety from exposure to hazardous chemicals (Risda, 2022). In the pursuit of producing delicious and appealing food, food additives (Bahan

Tambahan Pangan or BTP) are often used. These additives enhance the appearance and taste of food to meet consumer preferences. The use of food additives dates back to ancient times, as seen in ancient Egyptian society, where salt and spices were used for food preservation.

The primary purpose of adding food additives is to improve nutritional value, enhance aesthetic and sensory qualities, and extend shelf life. According to the Indonesian Ministry of Health Regulation (Permenkes) No. 033 of 2012 concerning food additives, BTPs are used for similar purposes. Food additives or additive substances are not consumed on their own but are added during food processing to improve the overall quality of the food.

Additives are classified into two categories based on their origin: natural additives and synthetic additives. Additionally, food additives can be categorized into two types based on how they are introduced into food: incidental additives (unintentionally added) and intentional additives (deliberately added) (Mardin et al., 2022). According to the Indonesian Ministry of Health Regulation No. 033 of 2012, the government has prohibited various substances from being used as food additives, including preservatives such as formalin, borax, salicylic acid, and diethyl pyrocarbonate; sweeteners such as dulcin; and texture enhancers such as potassium bromate.

The misuse of food additives—particularly those exceeding regulated dosages—can cause harm to the human body. Furthermore, the illegal use of prohibited food additives continues to be reported. Preservatives are compounds added to food to prevent spoilage, such as decay or fermentation, thereby extending shelf life. However, some preservatives are hazardous—borax, formalin, and salicylic acid, for example—and are still often used illegally, especially in school snacks.

The use of such harmful preservatives can lead to food poisoning, with serious consequences, including death. The World Health Organization (WHO) reports that approximately 2.2 million people die each year due to food poisoning, with a significant proportion being children. Therefore, strict monitoring of preservative use is essential to protect public health, especially that of children (Muawanah, 2023).

Borax, or Sodium Tetraborate, is a colorless crystalline powder that dissolves easily in water. Borax is typically used in non-food products, such as floor cleaners, pesticides, wood preservatives, and similar materials (BPOM RI, 2019). The use of borax in food can cause kidney damage and harm to the nervous system. In industrial applications, borax is commonly used as an antiseptic and antifungal agent for wood (Risda, 2022).

Boric acid and borax are often misused by certain food producers to improve the taste, texture, and color of food—examples include noodles, meatballs (bakso), macaroni, crackers, snacks, and rice cakes (lontong). However, the use of boric acid and borax in food is strictly prohibited because

they are toxic to all human cells and pose serious health risks (Kumara et al., 2019).

The clinical symptoms of borax poisoning are characterized by a variety of signs, including upper abdominal pain, vomiting, diarrhea, headache, restlessness, severe skin conditions, pale face and sometimes bluish skin, shortness of breath, circulatory failure, fluid loss, liver and kidney degeneration, as well as muscle tremors in the face and limbs followed by seizures. Other symptoms may include urinary retention, jaundice, loss of appetite, mild diarrhea, recurring headaches, and in severe cases, death.

Several types of food commonly found to contain borax include meatballs (bakso), rice cakes (lontong), noodles, crackers, and various traditional foods such as lempeng and alen-alen. In some regions, borax is known by local names such as "garam bleng," "bleng," or "pijer," and is often used to preserve rice, which is then processed into traditional foods known as legendar or gendar (Mudzkirah, 2016).

A simple technology that can be used to detect the presence of borax is the curcumin compound, a natural yellow pigment found in the rhizomes of turmeric (Curcuma domestica Val.) and Java turmeric (Curcuma zanthorrhiza). Curcumin acts as a borax indicator through a visible color change—from yellow to brownish—in the presence of borax (Raisani, 2013).

According to Aristyani and Rohmayanti (2024), turmeric is one of the natural materials that can be used to detect the presence of borax. The rhizome of turmeric contains several chemical compounds, including essential oils, starch, fiber, and ash. The main components in turmeric rhizomes are curcuminoids and essential oils (Cahya & Prabowo, 2019).

Curcumin is one of the active compounds found in the rhizomes of Curcuma species. It has a variety of benefits, one of which is its function as an anti-inflammatory agent. Curcumin works by inhibiting molecules involved in the inflammatory process, such as phospholipase, lipoxygenase, COX-2, leukotrienes, thromboxanes, prostaglandins, nitric oxide, collagenase, elastase, hyaluronidase, MCP-1, interferon-inducible protein, tumor necrosis factor (TNF), and interleukin-12 (Febriawan, 2020).

Curcumin is a yellow-orange crystalline compound that is insoluble in ether but soluble in oils. This compound also behaves as an alkali, appearing reddish-brown in basic conditions, while in acidic environments it turns light yellow, which is why it is commonly used as a natural colorant (Darmawati, 2024).

According to research by Tarigan (2021), curcumin can be used to detect borax. An extract made from 250 grams of turmeric dissolved in 150 ml of water was shown to be effective in detecting borax compounds in food. This finding is further supported by a study conducted by Ginting (2016), which found that turmeric extract with a curcumin concentration of 1500 ppm required only 3 minutes for borax detection.

The presence of curcumin makes it a promising tool for borax detection in food. The working principle of curcumin in turmeric involves breaking down borax bonds into boric acid, which is then bound by curcumin to form a rosy-colored complex compound known as the boron-cyano-curcumin complex (Suprihatin et al., 2020).

This process demonstrates that turmeric can be used as a simple, effective, and affordable method for borax detection. Such a method not only enhances food safety but also provides additional benefits to both food products and consumers.

Turmeric rhizomes contain two primary chemical compounds: essential oils and curcuminoids. The essential oils are composed of sesquiterpene alcohols, including turmerone and zingiberene, while curcuminoids consist of curcumin and its yellow-colored derivatives, such as desmethoxycurcumin and bisdesmethoxycurcumin. In addition, turmeric rhizomes also contain gum, fat, protein, and minerals such as calcium, phosphorus, and iron.

The chemical composition of turmeric includes carbohydrates (3%), protein (30%), fat (5.1%), minerals (3.5%), and moisture (13.1%). Essential oils (5.8%) are obtained through steam distillation of the rhizomes, comprising compounds such as α-phellandrene (1%), sabinene (0.6%), cineole (1%), borneol (0.5%), zingiberene (25%), and sesquiterpenes (53%).

Curcumin (diferuloylmethane), which makes up 3–4% of the turmeric rhizome, is the main active compound responsible for its yellow color. It is composed of Curcumin I (94%), Curcumin II (6%), and Curcumin III (0.3%) (Kusbiantoro, 2018).

METHODS

The materials used in this study included 1 kg of fresh turmeric, purchased from the Ulee Kareng traditional market in Banda Aceh. Additionally, bamboo toothpicks (brand: Nanas) were used as curcumin sticks, totaling 50 pieces, along with artificially prepared meatballs. The research began with the preparation of curcumin sticks, followed by the production of artificial meatballs, with the following steps:

1. Preparation of Turmeric Extract
    b. Prepare 1 kg of turmeric, wash it thoroughly, and peel the skin (use gloves to avoid staining, as turmeric stains are difficult to remove).
    c. Grate the turmeric using a container, then immediately press the grated turmeric over a 300 ml beaker glass using cheesecloth to extract the juice.
    d. Cover the extracted juice and let it stand for 24 hours to allow the supernatant to separate, which will be used as the turmeric extract.

2. Preparation of Curcumin Sticks
   a. Prepare the sticks (toothpicks).
   b. Soak 50 sticks in 100 ml of curcumin extract in a beaker glass for 1 hour. The sticks should be immersed in an upright (vertical) position.
   c. After soaking, remove the curcumin sticks and dry them by air on a petri dish.

3. Preparation of Artificial Meatballs
   A. Positive Control
      a. Prepare 100 grams of meatball dough in each of three separate containers.
      b. Add borax in volumes of 1 ml (0.1%), 5 ml (0.5%), and 10 ml (1%) to each container respectively (Container A: 1 ml, Container B: 5 ml, Container C: 10 ml), then mix thoroughly.
      c. Take a small portion of the dough and shape it into meatballs.
      d. Boil the meatballs in boiling water until they float to the surface.
      e. The meatballs are then ready to be used.

   B. Negative Control
      a. Prepare 100 grams of meatball dough.
      b. Take a small portion of the dough and shape it into meatballs.
      c. Boil the meatballs in boiling water until they float to the surface.
      d. The meatballs are then ready to be used.

4. Borax Detection Procedure

   The procedure for detecting borax in artificial meatballs is as follows:
   a. Prepare the curcumin sticks.
   b. Insert the curcumin sticks into the artificial meatballs containing 0.1% borax (3 pieces), 0.5% borax (3 pieces), and 1% borax (3 pieces). Use three meatballs for each exposure time of 1 minute, 5 minutes, and 10 minutes.
   c. After each time interval, remove the curcumin sticks and observe any color changes on the sticks.
   d. The same procedure is conducted for both the positive and negative borax control meatballs.

e. Data is collected by directly observing the color change on the curcumin sticks over time; if the stick turns red, the borax test is positive.

RESULTS AND DISCUSSION

The results obtained from the use of curcumin sticks to detect borax in meatball snacks can be seen in Tables 1 and 2

Table 1. Borax Detection Using Curcumin Sticks (Data I)

No.	Media	Time (Borax)		
		1 minute	5 minute	10 minute
1	Negative Control	Negative (-)	Negative (-)	Negative (-)
2	Meatball with 0.1% Borax	Negative (-)	Negative (-)	Negative (-)
3	Meatball with 0.5% Borax	Negative (-)	Positive (+)	Positive (+)
4	Meatball with 1% Borax	Positive (+)	Positive (+)	Positive (+)

The observation data from Experiment I indicate that the curcumin sticks were effective in detecting 1% borax in meatballs within 1 minute, 5 minutes, and 10 minutes. However, at a borax concentration of 0.5%, detection was only possible after more than 5 minutes. The curcumin sticks were unable to detect borax at a concentration of 0.1%. Subsequently, the experiment was repeated, and the results can be seen in Table 2.

Table 2. Borax Detection Using Curcumin Sticks (Data II)

No.	**Media**	**Time (Borax)**		
		1 minute	5 minute	10 minute
1.	Negative Control	Negative (-)	Negative (-)	Negative (-)
2.	Meatball with 0.1% Borax	Negative (-)	Negative (-)	Negative (-)
3.	Meatball with 0.5% Borax	Negative (-)	Positive (+)	Positive (+)
4.	Meatball with 1% Borax	Positive (+)	Positive (+)	Positive (+)

The data in Table 2 are not significantly different from or are similar to the data in Table 1. Therefore, overall, the research was sufficiently conducted with two trials since they produced consistent results.

From Tables 1 and 2, it can be observed that after applying the curcumin sticks to meatballs containing borax at concentrations of 0.1%, 0.5%, and 1%, there were differences in the results. For the 0.1% borax meatballs, no color change occurred on the curcumin sticks; they remained yellow at 1 minute, 5 minutes, and 10 minutes. Meanwhile, in the 0.5% borax meatballs, color changes on the curcumin sticks occurred at 5 minutes and 10 minutes. The most effective borax detection was in the 1% borax meatballs at 1 minute, 5 minutes, and 10 minutes, indicating that the 1% concentration was

effective, as shown by the color change of the curcumin sticks from yellow to red.

DISCUSSION

Curcumin sticks are wooden sticks coated with curcumin, used as a practical borax detection tool that can be applied outside the laboratory. The curcumin sticks operate based on the same principle, utilizing curcumin as an indicator for sodium tetraborate (borax), which produces a red color (Safitri et al., 2019). Curcumin functions as an indicator to detect the compounds $Na_2B_4O_7$ (borax) or H_3BO_3 (boric acid).

The results of this study show that curcumin does not react with borax within 1 minute, thus it cannot detect borax in meatballs at that time. This occurs due to the low concentration of borax present in the meatballs, causing curcumin not to react within 1 minute. However, after 5 minutes, the curcumin stick changes color to reddish-orange, indicating that curcumin has reacted with borax. Similarly, at 10 minutes, the curcumin stick turns red due to the reaction between curcumin and borax. The longer the exposure time, the more intense the color change becomes. Conversely, the higher the concentration, the faster the borax can be detected. This occurs when the curcumin stick containing turmeric extract (as a borax detection tool) is inserted or applied to food containing borax; the indicator will change color from yellow to reddish-orange and eventually to brick red, depending on the borax concentration in the meatballs (Surahmaida, 2021).

Curcumin compounds can break the basic bonds of borax ($Na_2B_4O_7 \cdot 10H_2O$) into boric acid (H_3BO_3), then bind to form a boron cyano curcumin complex, which has an orange-reddish to reddish-brown color. This color appears due to the formation of the compound rosocyanine through the reaction between curcumin and borax, indicating the presence of borax in food products (Sari, 2020). The following is the reaction that forms rosocyanine, resulting in a red-colored solution.

$$Na_2B_4O_7 + C_{21}H_{20}O_6 \rightarrow B[C_{21}H_{19}O_6]_2Cl$$

Borax + curcumin → rosocyanine

Figure 1. Reaction forming rosocyanine

Borax is a chemical compound in the form of odorless white crystals that is toxic and hazardous. Borax is not permitted as a Food Additive (BTP). When accumulated in the body, borax can trigger various health disorders, including cancer, and even poses a risk of death (Surahmaida, 2021).

Borax can affect food by improving its structure and texture. For example, adding borax to meatballs makes them chewier and extends their shelf life. However, the difference between food containing borax and food

without it is difficult to detect using only the five senses. Therefore, special laboratory testing is required to detect it (Dolot et al., 2021).

CONCLUSION

The results of this study concluded that there is an innovation of a simple tool to detect the presence of borax in meatballs using a readily available natural material, turmeric, which is applied onto sticks to create curcumin sticks. These curcumin sticks are capable of detecting borax concentrations above 0.1% with the fastest detection time of 5 minutes.

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