The Performance of Turmeric Paper as an Indicator of The Borax Content in Crackers

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Abstract. Borax is one of food additives that has been prohibited from being used by the Indonesian Government because it is dangerous to health. However, the fact is that borax has been widely added to several food products, such as skewered meatballs, school children's snacks, bread, meatballs, tofu and crackers. Crackers containing borax is easily found in traditional markets. Short-term consumption of borax can cause various symptoms such as headache, fever, malaise, nausea or vomiting, pain in the upper abdomen and diarrhea. While long-term exposure to borax will have a more dangerous effect, which can cause stomach disorders, seizures to acute kidney failure which can lead to death. This paper reports a simple, easy and inexpensive test of borax content using a home-made turmeric paper on ten types of crackers purchased randomly in traditional market. The aim is that the borax content test can be carried out by anyone only by buying a few ingredients from the local market and pharmacy, and without the need to involve laboratory tests, but with accurate results when compared to laboratory tests. As a comparison, a flame test and a colour test on the borax content carried out in the laboratorium using the AOAC 18 ed. 2005 Official Method Boric Acid & Borates in Food 970.33 and the FI ed. V of 2014 General Identification Test <291> Borat method A on Page 1423 was also completed. Among the 10 crackers tested, six of them were detected to contain borax. These results are very consistent with the laboratory test results. The performance of the home made turmeric paper is therefore reliable.

1. Introduction
Borax is a mixture of high concentration white mineral salts containing Boron (B) and Oxygen (O) atoms which has the chemical designation Sodium tetraborate decahydrate with the molecular formula Na₂B₄O₇·10H₂O or Na₅[B₂O₅(OH)]₈H₂O, CAS number 1303-96-4, HS Code 28401990, has a molecular mass of 381.37 Daltons [1]. The types of borax commonly used include sodium biborate, sodium piborate, disodium tetraborate, sodium borate decahydrate, boric acid, disodium salt, antypionin, boracsu, boracin, jaikin, neobar, polybor. Borax is an odorless powder or crystal. This chemical is easily soluble in water, glycerol and alcohol, but insoluble in acid. If it dissolves in water it will form sodium hydroxide and boric acid (H₃BO₃).

Sources of borax in nature are from places containing evaporation deposits, such as salt mines and mud craters in Bledug Kuwu, Central Java. Borax is also known locally as bleng water if it is in the form of a clear solution, or bleng salt if it is in solid crystalline form. The method of making borax is similar to the traditional way of producing salt. Bleng mineral water is poured into bamboo, then dried. The result is a solid or liquid bleng which is an impure form of boric acid. Borax is widely used in various non-food industries, such as in the paper, wood, plastic, ceramic and glass industries [2]. Apart from being an inorganic preservative, borax is also a powerful microbial killer. Pyrex glasses or
chemical laboratory glassware can have a very strong performance against heat because they are made with a mixture of borax. Borax's extraordinary preservative power is probably derived from active boric acid. Boric acid (H₃BO₃) is a weak monobasic Lewis boron acid that is often used as an antiseptic, insecticide, fire retardant, neutron absorber, or precursor to other chemical compounds such as pharmaceutical products, soaps, mouthwashes, toothpastes and eye washes. However, globally, boric acid was reported to have been used as an additive in food products with the aim of extending the level of freshness of food and improving the quality of food texture. As in Malaysia, boric acid has been used in various noodle products and seafood-based processed foods [3,4]. In China, boric acid has been added on soybean products, rice products, aquatic products and other dried food products [5]; although most of the production of traditional staple foods in China (i.e. noodles and steamed bread) has also been reported to use natural additives including salt, wheat gluten and enzymes [6]. In the United States, boric acid has long been used in caviar and dried apricot products [7]. Consumption of foods containing boric acid has been reported to have adverse effects on human and animal health, ranging from poisoning with borax itself, to damage to the immune system and immune-related genes [8–11]. Detection of boric acid content in food has also been reported [12,13].

Like boric acid, borax is also very dangerous for human health if it is inhaled, drunk, ingested and then enters the human body in large quantities. In a short term, consumption of borax can cause various symptoms including dizziness, vomiting and diarrhea [14]. Long term consumption of foods containing borax will result in the accumulation of carcinogenic borax chemicals in human organs such as the liver, brain, kidneys and testes [1,2]. Consumption of high enough borax can cause symptoms of stomach cramps, kidney damage and even death if the dose of borax toxin has reached 10-20 grams. Pongsavee [15] reported that the accumulation of borax in the human body can cause damage to immune cells and chromosomes. The safe limit for using borax in food legally is 1 gram per 1 kilogram of food (1/1000) [2]. Due to its carcinogenic impact on human health, the Indonesian Government has officially banned the use of borax as an additive in food production processes [1]. Detection of borax content both qualitatively and quantitatively in food products has also been widely reported, including using curcumax reagent [16], natural indicator [17,18], optical fiber [19], UV-Vis spectrophotometry [20], by observing physical conditions and testing using BaCl₂ solution [21].

However, in many local communities, both in the city and in the countryside in Java, many food producers add borax to several products, such as meatballs [20,21], school children's snacks [22,23], bread [24], meatballs and pempek [25], tofu [26] and crackers. Tofu whose production process uses borax is sharp, very tasty and has a bitter taste on the tongue. Meatballs containing borax tend to be white, not brownish like the use of meat. When bitten, the meatballs return to their original texture, chewy and tend to be hard. The existence of crackers containing borax is easily found in traditional markets.

Based on that, in order to prevent the public from being exposed to the borax contained in traditional crackers, it is necessary to think about ways so that people can test the borax content independently, easily, simply and cheaply, but with results that remain accurate without the need to spend money on laboratory test fees, using certain chemicals, or advanced test facilities as reported above. In this present work, ten kinds of traditional crackers purchased at random from a stall in one of the traditional markets in Nganjuk were used as the test samples. What is meant by a turmeric paper is a filter paper that has been soaked in a liquid solution of turmeric starch for a while, then aerated. A sheet of filter paper can be purchased at a local pharmacy for a very cheap price. When turmeric paper is immersed in a liquid solution of crackers containing borax, it will change colour from yellow to brownish red due to the reaction that occurs between curcuma (contained in turmeric paper) and borax in borax. The redder the turmeric paper colour, the more borax content in the crackers. As is known, turmeric (Curcuma domestica Val.) is one of the native spices and medicinal plants from the Southeast Asian region which has many benefits such as a kitchen spice, natural colorant in food, cosmetics and as a family medicine [27]. The compound that is thought to play an important role in turmeric is curcuma [27,28]. According to Halim [29], curcuma can bind to boric acid which then forms a red rosocyanine component so that it can be used as a borax detection test.
2. Experiment

2.1 Turmeric paper preparation

Five hundred grams of fresh turmeric were cleaned, mashed, squeezed and filtered to produce a liquid solution of turmeric starch. 76 % alcohol as much as 10 % of the total turmeric extract solution to be made is added so that the ratio between the turmeric extract solution and alcohol was 9 : 1. A sheet of filter paper was cut into 3x3 cm² size and dipped in the turmeric extract solution for 5-6 minutes, drained and aerated. After drying, the turmeric paper was stored in a closed container. Turmeric paper was then ready to use.

2.2 Preparation of test crackers and borax content testing

Ten kinds of crackers were purchased from one of the traditional markets in Nganjuk East Java. The intended crackers were labelled “K (stands for krupuk) Berkah 1”, “K. Emas 3”, “K. Ikan Kakap 11”, “K. Lempeing 14”, “K. Berkah 13”, “K. Batang 15”, “K. Makaroni 12”, “K. Ikan Nona 10”, “K. Cap Ikan 9”, and “K. Rahayu 8”. Each was then crushed and placed in a separate small bowl, added with mineral water until all the flakes of the crackers was submerged and stirred homogeneously and left for a while before being tested for borax content. The turmeric paper was dipped in the cracker solution until it was submerged for about 5 minutes. Lifted and checked the colour. When the colour of the turmeric paper changes to reddish brown, it means there is an indication that the crackers contain borax.

Confirmation of the borax content in all the test crackers were then carried out at the Testing Service Unit (TSU) of the Faculty of Pharmacy, Airlangga University, Surabaya using the following methods: (1) AOAC 18 ed. 2005 Official Method of Boric Acid & Borates in Food 970.33 and (2) FI ed. V Year 2014 General Identification Test <291> Borat way A Page 1423.

2.3 Qualitative test of borax at the TSU laboratory

For each test cracker, 100 grams of mass was needed to be ground and then ashed in the furnace. The ash was divided into two equal parts. The first part is for the flame test, while the second part is for the spot (colour) test. The flame test was carried out by acidifying the ash, i.e. by giving a few drops (1 ml) of concentrated sulfuric acid (H₂SO₄ 36 N) to the ash in such a way that all the ash becomes wet. A few drops of methanol was then added and the sample was ignited. When the color is green, the sample contains borax because borax actually contains the element boron (B), which has a green flame colour when heated. The second ash is dissolved in HCl then the solution was smeared on a curcumin paper. When there is a brick red stain, the sample contains borax. The curcumin paper was prepared in the following way: 1 g of curcumin (pro analysis grade) was dissolved in 100 ml of Ethanol Absolute (pro analysis grade). Then the filter paper was immersed in the solution. Allow the curcumin paper to dry without using an oven or other heater. Figure 1 shows the flow chart of the borax test as described above.

![Figure 1](Image)

Figure 1. Flow chart showing the experimental procedure followed in this work
3. Results and Discussion

Figures 2-11 shows the results of the borax test in the ten kinds of crackers using the turmeric paper and their comparison using the results of the TSU laboratory test.

**Figure 2a.** The turmeric paper was soaked in the cracker “K. Berkah 1”. The paper colour turns reddish brown.

**Figure 2b.** The results of the borax test on "K. Berkah 1" crackers from the TSU laboratory: Positive → contains borax.

**Figure 3a.** The turmeric paper was soaked in the cracker “K. Emas 3”. The paper colour remains yellow, does not change.

**Figure 3b.** The results of the borax test on "K. Emas 3" crackers from the TSU laboratory: Negative. → doesn’t contain borax.
Figure 4a. The turmeric paper was soaked in the cracker “K. Ikan Kakap 11”. The paper colour turns reddish brown.

Figure 4b. The results of the borax test on "K. Ikan Kakap 11" crackers from the TSU laboratory: Positive → contains borax.

Figure 5a. The turmeric paper was soaked in the cracker “K. Lempeng 14”. The paper colour turns reddish brown.

Figure 5b. The results of the borax test on "K. Lempeng 14" crackers from the TSU laboratory: Positive → contains borax.
**Figure 6a.** The turmeric paper was soaked in the cracker “K. Berkah 13”. The paper colour remains yellow, doesn’t change.

**Figure 6b.** The results of the borax test on “K. Berkah 13” crackers from the TSU laboratory: Negative → doesn’t contain borax.

**Figure 7a.** The turmeric paper was soaked in the cracker “K. Batang 15”. The paper dan the liquid colour both turns very strong brownish yellow.

**Figure 7b.** The results of the borax test on “K. Batang 15” crackers from the TSU laboratory: Positive → contains borax.
Figure 8a. The turmeric paper was soaked in the cracker “K. Makaroni 12”. The paper colour turns yellowish brown.

Figure 8b. The results of the borax test on “K. Makaroni 12” crackers from the TSU laboratory: Positive.

Figure 9a. The turmeric paper was soaked in the cracker “K. Ikan Nona 10”. The paper colour turns reddish brown.

Figure 9b. The results of the borax test on “K. Ikan Nona 10” crackers from the TSU laboratory: Positive → contains borax.
Figure 10a. The turmeric paper was soaked in the cracker “K. Cap Ikan 9”. The paper colour turns remains yellow, doesn’t change.

Figure 10b. The results of the borax test on “K. Cap Ikan 9” crackers from the TSU laboratory: Negative → doesn’t contain borax.

Figure 11a. The turmeric paper was soaked in the cracker “K. Rahayu 8”. The paper colour turns remains yellow, doesn’t change.

Figure 11b. The results of the borax test on "K. Rahayu 8" crackers from the TSU laboratory: Negative → doesn’t contain borax.
As shown in Figures 2, 4, 5, 7, 8 and 9, the turmeric papers have changed colour to reddish brown or brownish yellow. Even in Figure 7, the cracker solution also changes the colour to very strong brownish yellow! Meanwhile, the results of the TSU laboratory test on the associated crackers confirmed that the crackers were positive, i.e. those crackers indeed contain borax. While the colour of the turmeric papers in the other crackers in Figures 3, 6, 10 and 11 all remained yellow, unchanged, indicating that the crackers in the Figures 3, 6, 10 and 11 did not contain borax. The results of the TSU laboratory test confirmed the correctness of these indications because the TSU’s results were negative. Previously, the borax test by means of a flame test and a colour test had been reported by Hardiana on commercially produced bread and traditionally made bread in Blang Pidie District [24]. Among all the test samples, none were indicated to contain borax. No borax test was performed with turmeric paper as reported by the authors. As far as the author is aware, there are no publications that report the results of testing for borax by means of a flame test and a colour test. Turmeric paper is therefore very suitable to be used as the first indicator of the borax content in food using turmeric paper independently, as reported by the authors, without the involvement of laboratory tests. Based on a series of tests for the borax content in the ten crackers using the turmeric paper reported in this work, where the test results are very consistent with the TSU laboratory test results, it can be concluded that turmeric paper has acted as a good indicator of the borax content in the crackers.

4. Conclusion
A series of experiments on the borax content in the crackers using turmeric papers have been completed. The results are in close agreement with the TSU laboratory test results. Turmeric paper is therefore very suitable to be used as the first indicator of the borax content in food, not limited in crackers.

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