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# Assessment of Borax Contamination in Crackers from Jenangan Subdistrict Market: Findings and Recommendations

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**ABSTRACT** Borax is a non-permitted food additive according to the Regulation of the Minister of Health of the Republic of Indonesia No. 033/2012, due to its hazardous effects on human health, including disruption of the central nervous system, kidney and liver function, and in severe cases, death. Despite this prohibition, borax continues to be used illicitly in food products such as crackers to enhance texture and shelf life. This study aimed to assess the presence of borax in cracker products sold at the Jenangan Subdistrict Market in 2023. A descriptive research design was employed, using both organoleptic testing and qualitative rapid testing with curcumin test strips. A total of 21 cracker samples were collected through total sampling from three different vendors. Organoleptic evaluation assessing smell, taste, texture, and color was conducted by 30 non-standardized panelists, while the rapid test method was applied to detect borax content. The organoleptic results showed that all samples were rated positively in terms of smell and taste; however, 3 samples exhibited a texture that was difficult to crush, and 6 samples had a dull or dark color. The rapid qualitative test revealed that 3 out of 21 samples (14.3%) tested positive for borax, as indicated by a color change on the curcumin test strips from yellow to red or brick red. These findings indicate ongoing use of borax in local cracker products. It is recommended that food producers be educated about the health risks associated with borax and encouraged to adopt safer alternatives. Furthermore, public awareness and government regulatory enforcement should be strengthened to ensure the safety of food products in local markets.

**INDEX TERMS** Borax, crackers, curcumin test, food safety, qualitative analysis

## I. INTRODUCTION

Food safety remains a critical public health concern globally, especially in developing countries where food adulteration practices persist. One such hazardous practice is the illegal use of borax (sodium borate) as a food additive to improve texture and shelf life in various products such as noodles, meatballs, tofu, and crackers. Despite being banned under Indonesian Ministry of Health Regulation No. 033 of 2012 [1], borax continues to be detected in food products across local markets, posing significant health risks. Consumption of borax, even in small amounts, can lead to acute and chronic health complications including gastrointestinal distress, liver and kidney damage, neurological disruption, reproductive issues, and in extreme cases, death [2]–[4].

Crackers (locally known as kerupuk) are among the most frequently consumed traditional snacks in Indonesia and are often targeted by food producers seeking to enhance crispness and durability. Unfortunately, these products are highly susceptible to the addition of harmful chemicals, including borax, due to weak surveillance mechanisms and limited consumer awareness [5], [6]. Studies conducted in various regions of Indonesia have consistently identified borax in traditional food products sold in markets [7]–[9], indicating systemic gaps in food safety enforcement.

Recent developments in food analysis have introduced more rapid and accessible detection techniques for borax, such as the curcumin test strip method. This method offers a simple, affordable, and sensitive alternative for detecting borax residues in food samples. The curcumin reagent changes color from yellow to orange-red in the presence of borax, enabling visual confirmation without the need for advanced instrumentation [10]–[13]. Compared to instrumental methods such as spectrophotometry and chromatography, which are accurate but costly and time-consuming [14], [15], curcumin-based tests are particularly suitable for low-resource settings and field-based inspections.

However, despite the availability of such methods, there is a lack of systematic surveillance data on borax contamination in cracker products at the local market level, especially in suburban regions like Jenangan Subdistrict. Moreover, few studies integrate both organoleptic (sensory) assessment and chemical detection to evaluate food quality comprehensively. Most prior studies either focus solely on laboratory-based detection or lack contextual relevance to local consumer environments [16]–[18].

Therefore, this study aims to assess the presence of borax in cracker products sold in the traditional market of Jenangan

Subdistrict using a combination of organoleptic evaluation and qualitative rapid testing with curcumin test strips. The integration of sensory and chemical analysis provides a more holistic understanding of food safety at the consumer level.
The key contributions of this study are as follows:
1. Development of a simple, dual-approach protocol for detecting borax in traditional snack products using both organoleptic and chemical indicators.
2. Generation of localized surveillance data on the prevalence of borax in crackers sold in Jenangan Subdistrict, contributing to regional food safety mapping.
3. Practical recommendation for regulatory and educational outreach, particularly for small-scale food producers and market vendors, to promote safer food production practices.

## II. METHOD

### A. STUDY DESIGN
This research utilized a descriptive observational design with a cross-sectional approach. The study was conducted prospectively and aimed to assess the presence of borax in cracker products sold at the Jenangan Subdistrict Market. The research employed both organoleptic tests and qualitative rapid testing using curcumin test strips to detect borax contamination in food samples. This method was chosen due to its simplicity, affordability, and effectiveness in detecting borax in various food matrices [26], [27].

### B. STUDY LOCATION AND TIMEFRAME
The research was conducted in Jenangan Subdistrict, Ponorogo Regency, focusing on the traditional market area, where a wide range of cracker products are sold. Data collection and sample analysis were carried out over the course of one month in 2023, aligning with the period of peak cracker sales to ensure sample relevance and diversity.

### C. POPULATION AND SAMPLING
The target population consisted of **all cracker products** sold by vendors in the Jenangan market. The sampling technique used was **total sampling**, where all available cracker types that met the inclusion criteria were collected for analysis. In total, **21 different cracker samples** were collected from **three vendors** operating in different sections of the market. This approach ensured representative coverage of the available product variation while maintaining feasibility in testing [28]. The inclusion criteria for sample selection were:
1. Cracker products visibly displayed for sale at the market.
2. Products marketed as ready-to-eat and not pre-packaged with nutritional labeling.
3. Products purchased directly from vendors during the study period.

No randomization was applied, as the study did not involve human subjects or experimental treatment groups.

### D. MATERIALS AND TOOLS
All tools used in the analysis were cleaned and sanitized before use to avoid cross-contamination between samples. The materials and instruments used in this study included: Cracker samples (21 varieties) purchased from three local vendors; Curcumin test paper strips, prepared based on a modified protocol from prior studies for borax detection [29]; Distilled water, used to extract aqueous solutions from cracker samples; Mortar and pestle for sample crushing; Dropper pipettes, clean beakers, and glass rods for solution handling and mixing; Panelist assessment form for organoleptic testing (color, texture, smell, taste); Documentation tools, including notebooks and cameras.

### E. ORGANOLEPTIC TESTING
Organoleptic testing was conducted by 30 untrained panelists, consisting of students and adult volunteers who met general health criteria. The test assessed four key sensory attributes of each cracker sample: color, texture**,** smell, and taste. Panelists recorded their observations using a simple hedonic scale form. Particular attention was given to identifying any unusual characteristicssuch as overly hard textures or a bitter aftertaste that may be associated with borax presence [30]. The results of organoleptic testing were used to identify samples that warranted further chemical verification. Organoleptic assessments also offered insights into how borax contamination may alter the sensory profile of food.

### F. BORAX DETECTION USING CURCUMIN TEST STRIPS
Each cracker sample was first crushed using a mortar and pestle. A portion of the crushed material was mixed with 10 mL of distilled water and stirred thoroughly to extract soluble compounds. The resulting solution was allowed to settle before testing.Curcumin test paper, prepared by soaking filter paper in a curcumin–ethanol solution and drying it at room temperature, was then used for qualitative analysis. One drop of the supernatant from each sample solution was applied to the curcumin strip. The presence of borax was indicated by a color change from yellow to red, orange-red, or brick red [31], [32]. This colorimetric method is based on the chemical reaction between borate ions and curcumin, forming a red-colored complex known as rosocyanine, which provides visual confirmation of borax contamination [33].

### G. DATA RECORDING AND ANALYSIS
All test results were recorded manually and summarized in tables. The proportion of samples testing positive for borax was calculated and expressed as a percentage. Organoleptic test results were analyzed descriptively by summarizing the frequency of specific sensory characteristics (e.g., hard texture, dark color). Samples testing positive in the curcumin test were compared with their organoleptic profiles to identify potential sensory indicators of borax use.

Due to the descriptive nature of the study and the qualitative method used, no inferential statistics were applied. However, the data provide important insights into the extent of borax contamination in local market products and serve as a basis for future quantitative research or regulatory monitoring [34].

### H. ETHICAL CONSIDERATIONS
As this study did not involve human or animal testing, no ethical clearance was required. All sample acquisitions were conducted through public market purchases, and no personal data were collected. However, ethical research principles were followed, including transparency in vendor

engagement and the use of results for public health advocacy [35].

## III. RESULTS

### A. ORGANOLEPTIC TEST

The organoleptic test was conducted by non-standardized panelists with a total of 30 panelists by observing the smell, taste, texture, and color of the crackers. The results of TABLE 1 above show that of the 21 samples examined, 100% have a good category in the quality of cracker odor with assessment criteria for the good category which has the characteristics of a strong raw material odor and no musty odor. However, each panelist has a different assessment for each sample. This is because each panelist has different sensitivities and basically the human senses also vary.

TABLE 1
Results of Odor Quality Assessment on Crackers in Jenangan Sub-District Market

| Odor quality | Frequency (f) | Percentage (%) |
|---|---|---|
| Good | 21 | 100% |
| Suffient | 0 | 0% |
| Less | 0 | 0% |

TABLE 2
Results of Taste Quality Assessment on Crackers in Jenangan Sub-District Market

| Taste quality | Frequency (f) | Percentage (%) |
|---|---|---|
| Good | 21 | 100% |
| Suffient | 0 | 0% |
| Less | 0 | 0% |

From the results of TABLE 2 above, it was found that out of 21 samples examined, 100% had good criteria on the taste quality of crackers after frying with assessment criteria for the good category which has the characteristics of savory crackers, there is a taste of raw materials, and a little flavoring. However, each panelist had different ratings on each sample. This is because each panelist has different sensitivities and basically the human senses are also different.

TABLE 3
Results of Texture Quality Assessment on Crackers in Jenangan Sub-District Market

| Texture quality | Frequency (f) | Percentage (%) |
|---|---|---|
| Good | 18 | 85.7% |
| Suffient | 2 | 9.5% |
| Less | 1 | 4.8% |

The results of TABLE 3 above show that of the 21 samples examined, 85.7% had good criteria, 9.5% had sufficient criteria, and 4.8% had insufficient criteria on the texture quality of crackers with assessment criteria of for the good category having characteristics that are easy to crush, for the sufficient category having characteristics that are slightly/less crushable, and for the insufficient category having characteristics that are difficult to crush. The fair and poor assessment categories are caused by the texture quality characteristics of crackers that are slightly harder to crush than crackers in the good category.

From the results of the TABLE 4 above, 71.4% of the 21 samples examined had good criteria, 19.1% had sufficient criteria, and 9.5% had poor criteria on the color quality of crackers with assessment criteria for the good category having bright and clean color characteristics, for the sufficient category having less bright and slightly dull color characteristics, and for the poor category having characteristics that tend to be dark and look dull. In the fair and poor assessment categories, the color quality characteristics of the crackers are slightly duller than the crackers in the good category.

TABLE 4
Results of Color Quality Assessment on Crackers in Jenangan Sub-District Market

| Color quality | Frequency (f) | Percentage (%) |
|---|---|---|
| Good | 15 | 71.4% |
| Suffient | 4 | 19% |
| Less | 2 | 9.5% |

### B. QUALITATIVE TEST

The borax qualitative test was conducted using the curcumin paper test method using the rapid test with positive results indicated by changes in curcumin paper to orange, red, or brick red color. The borax qualitative test on these crackers uses the rapid test method. This method is a rapid test kit containing a bottle of borax reagent and curcumin test paper. The borax rapid test method is carried out by observing the color change that occurs on the curcumin paper test strip after dipping it into the food test sample. The following are the results of the physical quality inspection of the crackers:

TABLE 5
Qualitative Test Results of Borax Crackers Sold in Jenangan Subdistrict Market

| Borax content | Frequency | Percentage (%) |
|---|---|---|
| Positive | 3 | 14,3 |
| Negative | 18 | 85,7 |

From the results of TABLE 5 above, were examined using the curcumin paper test method and 14.3% of the samples were positive for borkas. This is indicated by the color change on the curcumin paper from yellow to orange, red, to brick red. The color change on the curcumin paper is caused by the content of curcumin which can break the bonds of borax into boric acid and bind it into a red color. [14].

## IV. DISCUSSION

### A. INTERPRETATION OF ORGANOLEPTIC AND BORAX DETECTION RESULTS

The results of the organoleptic evaluation and rapid testing with curcumin strips revealed concerning evidence of borax usage in traditional cracker products sold in Jenangan Subdistrict Market. Among the 21 samples analyzed, three (14.3%) tested positive for borax through a clear color change on the curcumin test paper, shifting from yellow to red or brick red. This chemical reaction aligns with previous studies that confirm the curcumin-borate interaction as a valid detection method for borax [36].

Sensory analysis also supported these findings. The three samples that tested positive exhibited atypical organoleptic characteristics, particularly in terms of texture and color. These crackers had an unusually firm, difficult-to-crush consistency and a dull or darkened appearance. While smell and taste were rated positively by panelists, the physical texture of these items raised suspicion, correlating with known effects of borax in increasing the crispness and durability of food products [37].

This outcome suggests that organoleptic features, particularly hardness and color, may serve as practical early indicators of borax presence. However, because smell and taste did not deviate significantly from normal ranges, reliance on sensory evaluation alone may lead to underestimation of borax contamination. Therefore, the integration of chemical testing is essential for accurate detection.

The findings affirm the utility of curcumin-based test strips in community-based food surveillance. As shown in this study, the method is not only fast and cost-effective but also provides visually intuitive results that can be used by both health authorities and informed consumers. Curcumin strips have been increasingly adopted in developing countries due to their accessibility and sensitivity in detecting low levels of borax in various food matrices [38].

### *B. COMPARISON WITH SIMILAR STUDIES*

The findings of this study are consistent with prior research conducted in various regions of Indonesia and other low- to middle-income countries, where the use of non-permitted food additives such as borax remains prevalent despite regulatory prohibitions. For instance, Lestari et al. found that 12% of food samples in a traditional market in Central Java contained borax, with crackers and noodles being the most frequently contaminated items [39]. Similarly, Wahyuni et al. reported a 17% contamination rate in tofu and meatball samples sold in Surabaya markets [40].

Compared to these studies, the 14.3% contamination rate observed in this study reflects a similar level of concern, suggesting that borax misuse remains a widespread issue in Indonesia's informal food sector. The consistency in contamination rates across different regions underscores the limitations of current enforcement mechanisms and the urgent need for more robust food safety surveillance.

Furthermore, this study reinforces the applicability of curcumin test strips as a valid alternative to more complex laboratory-based techniques such as UV-Vis spectrophotometry or chromatography. While the latter methods offer higher accuracy and quantification capabilities, they are not always feasible in rural or resource-limited settings. Studies by Kurniawan et al. and Hasanah et al. have also demonstrated that curcumin paper can reliably detect borax at concentrations as low as 0.5 mg/L, making it highly effective for preliminary screening in field conditions [41], [42].

This study also adds value by integrating organoleptic assessment with chemical testing. While prior studies often focused exclusively on laboratory methods or sensory analysis in isolation, this dual-method approach enhances the validity and contextual relevance of the results. It allows for triangulation between subjective sensory impressions and objective chemical evidence, which strengthens the case for regulatory follow-up on suspect products. In contrast, some research has noted that reliance on sensory indicators alone may result in both false positives and false negatives. For example, Sutrisno et al. found that 23% of samples that appeared suspicious based on texture or color were not chemically contaminated, while 9% of visually normal samples tested positive for borax [43]. This finding support curcumin strips for low-cost validation.

### *C. LIMITATIONS AND IMPLICATIONS*

Despite producing valuable insights, this study has several limitations that must be acknowledged. First, the study's sample size was relatively small, involving only 21 cracker samples from three vendors. While the use of total sampling ensured that all available products were tested, the limited geographic scope and sample number restrict the generalizability of the findings. Future research should expand the sampling frame to include multiple markets across various districts to assess regional trends in borax contamination.

Second, the study was conducted using non-randomized sampling and untrained panelists for the organoleptic test. While this approach reflects real-world consumer perception and is valuable for initial surveillance, it may introduce subjectivity in sensory evaluation. Future studies could incorporate trained panelists or use standardized sensory analysis protocols to enhance reliability. Third, the study used a qualitative detection method, which does not provide information about the exact concentration of borax in contaminated samples. Although the curcumin test offers excellent preliminary screening capabilities, it cannot replace quantitative methods when precise measurement is necessary for legal or regulatory enforcement. Integration with quantitative spectrometric methods is recommended for follow-up investigations.

Nevertheless, the implications of the study are highly significant. The confirmed presence of borax in cracker samples poses a direct public health risk, particularly for vulnerable populations such as children and older adults who frequently consume these products. The findings highlight the urgent need for educational outreach to traditional food producers regarding the health hazards of borax and the legal consequences of its use. Awareness campaigns targeted at both vendors and consumers may empower communities to demand safer food products and hold sellers accountable.
Additionally, the results underscore the value of community-based food monitoring using affordable technologies. The curcumin strip method can be integrated into local health department protocols, school health units, or even community health posts (posyandu) to enhance grassroots food safety surveillance. As food adulteration is often driven by economic motives, local governments should also consider promoting safe food preservatives or additives as alternatives to borax. Finally, the study illustrates the potential of combining scientific tools with participatory approaches. Engaging community members in sensory evaluation and empowering them with simple testing tools bridges the gap between laboratory research and everyday food safety practices.

## V. CONCLUSION

This study was conducted to determine the presence of borax in cracker products sold in the traditional market of Jenangan Subdistrict by combining organoleptic evaluation and qualitative chemical analysis using curcumin test strips. The primary objective was to assess food safety risks associated with the illicit use of borax as a food additive, which remains a concern despite clear regulatory prohibitions. Organoleptic tests conducted on 21 cracker samples revealed that while all samples were acceptable in terms of smell and taste, three samples (14.3%) exhibited a notably hard texture, and six samples (28.6%) appeared dull or dark in color both characteristics associated with borax adulteration. The curcumin test further confirmed these suspicions, with 3 out of 21 samples (14.3%) testing positive for borax, as indicated by a color shift on the strip from yellow to red or brick red. These findings underscore the continued misuse of borax in food production, particularly in informal market sectors where surveillance may be limited. The use of curcumin strips in this context proved effective, offering a rapid, affordable, and visually clear method for detecting borax contamination. The integration of organoleptic and chemical assessments strengthens the reliability of the study and highlights the value of simple field-based testing for community-level food monitoring. However, limitations such as the small sample size, single geographic location, and lack of quantitative concentration data restrict broader generalization. Future research should focus on expanding the sample scope across different regions, incorporating quantitative analytical methods such as spectrophotometry, and exploring public education strategies to reduce the prevalence of harmful additives in food. Additionally, there is potential for developing enhanced test kits with higher sensitivity and incorporating digital analysis to assist field inspectors and consumers alike. These steps will contribute to improving food safety practices and regulatory effectiveness in local markets.

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## DATA AVAILABILITY
The data supporting the findings of this study are available from the corresponding author upon reasonable request.

## AUTHOR CONTRIBUTIONS
Ervalia Zamilanti Zilca conceived the study, designed the methodology, collected samples, and drafted the initial manuscript. Narwati supervised the research process, contributed to data analysis and interpretation, and critically revised the manuscript. Marlik managed laboratory testing and supported data validation. Rusmiati assisted with literature review and manuscript editing. Demes Nurmayanti coordinated project administration and reviewed the final manuscript. All authors approved the submitted version.

## DECLARATIONS
### *ETHICAL APPROVAL*
This study did not involve human subjects, animals, or personal data; therefore, ethical approval was not required. All food samples were purchased from public markets, and no personal identifiers were recorded.

### *CONSENT FOR PUBLICATION PARTICIPANTS.*
Not applicable.

### *COMPETING INTERESTS*
The authors declare that they have no competing interests

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