A review of the utilization of modified flour: local food potential

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Abstract

Indonesia’s wheat imports reached 11.22 million tons of wheat, ranked second in the world based on data from the United States Department of Agriculture (USDA) in 2021/2022. Wheat flour, which comes from wheat endosperm and has a high gluten content, is a taboo for those with celiac disease. The purpose of this review is to examine the development and potential of local food through flour modification to reduce the use of gluten, especially in food products such as bread, biscuits and noodles. Flour modification with chemical modification, physical modification, and biological modification technology methods can improve the characteristics and increase the physicochemical properties of the flour produced, while providing an integral role in cost savings, encouraging the utilization of local food, encouraging local farmers, and improving the agricultural system.

1 Introduction

The gluten-free (GF) market has been growing in recent years due to the increasing population diagnosed with celiac disease, and the popular trend to reduce gluten consumption [1–3]. Local foods have the potential to be processed in the context of food diversification to reduce the use of gluten [4]. Flour-based food diversification has greater potential to be developed because it is easily accepted by the general public [5]. Some types of local food that have the potential to be developed as raw materials in flour processing include corn (Zea mays L.), cassava (Manihot esculenta), banana (Musa Paradisiaca), taro (Colocasia esculenta), yellow pumpkin (Cucurbita moschata) [6–10].

The flour modification process is carried out to improve the characteristics of the flour produced [11]. Flour modification can improve the physicochemical properties of flour so that it can be applied for flour substitution [12]. The technology of making flour itself is widely recognized by the community, both on a household scale, as well as in small and medium industries [13]. Therefore, technological innovations on non-rice foods derived from local food sources are needed. One of them can be done by introducing local food as a source of functional food [14–19] and the research conducted on local food shows that many of the local food products contain bioactive components that have certain metabolic functions for the health of the body when ingested. Therefore, our local food is no less competitive in terms of its functional food properties than imported products.

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The purpose of this review is to examine the potential of local food through flour modification to reduce the use of gluten, especially in food products that are often consumed by the public such as bread, biscuits and noodles. Flour modification with chemical modification, physical modification, and biological modification technology methods are also reviewed.

2 Modified Flour and Functional Properties

2.1 Bread Products

The addition of flour from other plant sources can increase the fiber, bioactive substances, and minerals, but affects some physical properties of bread such as bread volume, weight, specific gravity, and texture of bread [19]. In recent years, there have been several studies focusing on the application of modified flour from rice flour that has been physically modified by germination and pre-cooking processes to be applied to bakery products [20,21]. It was reported that germination of grain before processing into rice showed an increase in protein content, vitamin B1, and ash content compared to ungerminated rice [23]. It is reported that germination can reduce β-glucan but hydrolytic enzymes will be active, thus increasing the production of γ-aminobutyric acid (GABA), γ-orizanol, phenolic compounds, essential amino acids (lysine, niacin), and antioxidant activity. GABA has a number of physiological functions that are beneficial to health, including lowering blood pressure [24], controlling stress and improving sleep quality [25]. Based on research conducted the glycemic index value of precooked rice can be lower than the glycemic index of regular rice. Pratanak rice can cause a moderate increase in blood glucose levels, thereby improving insulin sensitivity and thus helping to prevent diabetes [27]. It stated in his research that the addition of modified rice flour has as much as 40% of consumer acceptance and the highest nutritional content in fresh bread products. The same thing from research using modified cassava flour (Manihot esculenta) and mocaf flour (Modified Cassava Flour) [15,16] reported that the results of fresh bread meet the applicable SNI requirements even though the rising power is lower than bread without mocaf although it is not too significantly different. This is because mocaf does not have gliadin and glutenin proteins so it can reduce gluten levels in bread with the addition of 20% mocaf along with the reduction in wheat flour used [28]. Phenolic compounds (scopoletin) are found in mocaf flour as antihypertensive, antioxidant, antiallergic, antidepressant, anticancer, and anti-inflammatory [29]. Sorghum seeds (Sorghum bicolor) are known to contain bioactive compounds that have beneficial properties such as hypocholesterolemia, anti-inflammatory, anti-cancer, anti-obesity, and anti-diabetes [30]. Sorghum-based usually results in bread with a small volume and a crumbly crumb [31]. This is due to the inability of the protein content in sorghum to regulate the structure of the bread [32]. Reportedly modified corn flour (Zea mays L.) will have high usability if utilized properly, one of which is as an ingredient in making fresh bread [11]. In fact, the study from [33] states that the ratio of the proportion of modified corn flour and wheat flour 30:70% produces good yellowish brown bread which is attractive due to the occurrence of the Maillard process in caramelization. The Maillard reaction is a reaction between reducing sugar groups and primary amine groups and produces a brown color. Fermented corn flour will experience the breakdown of starch granules into simpler forms due to the activity of cellulolytic enzymes produced by Lactobacillus, so the starch granules are hydrolyzed and cause hollow granules [34]. The functional properties of modified corn flour are beneficial for maintaining healthy skin, can prevent heart disease and stroke, has a high vegetable content which is a source of omega-6 fatty acids which are beneficial in the process of child growth and development [35].
2.2 Biscuit Products

Biscuits are globally recognized as a ready-to-eat food or snack [36]. Ready-to-eat biscuits have a relatively long shelf life and good food quality, from which biscuits are included in the category of foods that use modified flour better than bread [37,38]. A study of the formulation of making biscuits using modified banana kepok (Musa Paradisiaca forma typical) flour gave good value to the test of the level of liking on the attributes of taste, aroma, color, and texture with the formulation of modified banana kepok flour 50% of the research did not examine how the physicochemical properties and storage quality of the resulting biscuits so that further research needs to be done. In his research, the modification process of banana flour was carried out physically. Banana kapok flour was then modified through autoclaving, cooling, and heat moisture treatment. Modified banana flour has a low glycemic index so it can be controlled by blood sugar [40].

Other research on the characteristics of biscuits from modified korokratok (Phaseolus lunatus L.) modification process using spontaneously fermented korokratok flour using korokratok raw materials that have gone through the molding process first, then fermented for 16 hours at pH 5.5 has good technical functional properties including water holding capacity (WHC) 173.51 ± 26.13%, frothing power 28.22 ± 0.40 ml/g and emulsion power 313.50 ± 1.62 m2/g. The results of his research using modified korokratok flour and MOCAF had a significant effect on the physical (color and texture) and chemical (ash content, protein content, carbohydrate content, crude fiber content) characteristics of biscuits, but did not examine how the physical characteristics (color and texture).

2.3 Noodles Products

Dry noodles or instant noodles are fast becoming an alternative staple food consumed by modern civilization. This product is in high demand because it is easily available at a low price, practical, quick to serve, and has good taste [42]. A study utilizing the local food black glutinous rice (Oryza sativa. var. glutinosa) in noodle making [43]. Black glutinous rice has an anthocyanin content of 109.52 ± 256.61 mg/100 g. anthocyanin content which is the main component of an antioxidant is its functional property [44]. The modification used is physically using the moist heat method commonly called Heat Moisture Treatment (HMT). It was reported that the more HMT black glutinous rice flour substitution in the noodle product, the more the panelists liked it, but the higher the HMT black glutinous rice flour substitution in wet noodles caused a decrease in the level of liking. This is related to water absorption, where the relationship occurs because the higher the water absorption of the noodles, the more chewy the wet noodles will be due to the HMT modification process which changes the structure of starch granules to absorb water more easily [44]. The research utilized taro (Colocasia esculenta, L. Schott) in modified taro flour in noodle products. Modified taro flour contains high dietary fiber and carbohydrates [46]. The formulation of adding 10% HTM taro flour is the most preferred formulation by all panelists [47]. Another study optimized jali (Coix lacryma-jobi L.) as fermentatively modified flour [48]. It is reported that jali contains omega 3 and omega 6 which function to reduce and control sugar levels. In fact, the formulation using 25%–35% modified jali flour is still acceptable to panelists, the results of moisture and protein content of jali flour of 7.60% and 12.71% meet SNI-3751: 2009 (max 14.5% and min 7.00%), but the ash content of jali flour of 1.35% does not meet SNI. Another case is using bengkuang (Pachyrhizus erosus) for modified flour to make noodles. Bengkuang is a source of digestive fiber that can be used as an alternative component of functional foods [50]. The addition of modified bengkuang flour in making wet noodles can still be accepted by panelists up to 30%. It has chemical characteristics in the form of water content of 35.68% (bb), physical properties in
Table 1. Summary of the effect of modified flour on bread, biscuits, and noodles

<table>
<thead>
<tr>
<th>Product</th>
<th>Effect on product</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breads</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified rice flour (Oriza Sativa L)</td>
<td>Increased nutrient content, increased fiber, decreased texture</td>
<td>[20–22]</td>
</tr>
<tr>
<td>Cassava flour (Manihot esculenta)</td>
<td>Increased protein and fat content, has good expandability</td>
<td>[15,16,28,29]</td>
</tr>
<tr>
<td>Modified corn flour (Zea mays L.)</td>
<td>Increased nutrient content, more attractive color</td>
<td>[11,33]</td>
</tr>
<tr>
<td>Modified sorghum flour (Sorghum bicolor)</td>
<td>Small volume, crumbly breadcrumbs</td>
<td>[30–32]</td>
</tr>
<tr>
<td><strong>Biscuits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified banana kepok flour (Musa Paradisiaca forma typica)</td>
<td>Increased nutrient content; no undesirable effects on sensory properties, increased oil absorbency</td>
<td>[39,40]</td>
</tr>
<tr>
<td>Modified koro kratok flour (Phaseolus lunatus L.)</td>
<td>Increased crude fiber content, decreased protein content, hard texture</td>
<td>[41]</td>
</tr>
<tr>
<td><strong>Noodles</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified black glutinous rice flour (Oryza sativa. var. glutinosa)</td>
<td>Increased water absorption, acceptable for sensory evaluation</td>
<td>[43,44]</td>
</tr>
<tr>
<td>Modified taro flour (Colocasia esculenta, L. Schott)</td>
<td>Decreased expandability, darker color of the product</td>
<td>[45,46]</td>
</tr>
<tr>
<td>Modified jali flour (Coix lacryma-jobi L.)</td>
<td>Increased nutrient content, acceptable for sensory evaluation</td>
<td>[47,48]</td>
</tr>
<tr>
<td>Modified bengkuang flour (Pachyrhizus erosus)</td>
<td>Increased expandability and cooking loss, decreased protein value</td>
<td>[49,50]</td>
</tr>
</tbody>
</table>
3 Modified Technology

The most common methods of starch modification are chemical modification, physical modification, and biological modification. Chemical modification of starch includes cross-linking, acid hydrolysis, oxidation, and substitution. Physical modification of starch is by pre-gelatinization and hydrothermal treatment. Physical modification is the safest as it leaves no chemical residue behind. Biological modification (fermentation) can change the characteristics of natural flour. As the starch structure changes from crystalline to amorphous, it will increase amylose release and reduce pasting temperature in cassava flour fermented with lactic acid bacteria.

Acid modification will produce starch that is easier to digest, dissolves faster, and has a lower molecular weight. Modification with enzymes, usually using alpha-amylase enzymes, produces starch with stable viscosity at hot and cold temperatures and has good gel properties. Enzymes are able to affect the quality of the final product such as softening the crumb and also increasing the volume of the bread.

In general, research on the application of enzymes in biscuit development seems to be very limited. This may be due to the more reliable application of enzymes in bakery products. Therefore, further research using this method is expected in the future.

Cross-linking modification is done by reacting starch with compounds that can form cross-links at a certain pH temperature. The process is influenced by pH, temperature, and duration of the process. The cross-linking method causes changes in starch properties, namely the granules become stronger (not easily expanded), have high viscosity, acid resistance (low pH), resistance to stirring, and resistance to high-temperature cooking processes.

Modification by hydrothermal treatment can be divided into two, namely annealing and heat moisture treatment (HMT) techniques. The annealing technique is done by conditioning starch at a high moisture content and then heating it at a temperature below its gelatinization point. Heat moisture treatment (HMT) which is the confinement of starch or starchy materials of medium moisture content at high temperatures, has been known to increase the crystallinity of starch.

Oxidation modification is carried out using hydrogen peroxide, ammonium persulfate, peracetic acid, and sodium hypochlorite. This process is carried out wet. In this stage, pigment oxidation occurs, where hydroxyl oxidation becomes carboxyl and carbonyl. This process causes changes in starch properties, namely a whiter color, less prone to retrogradation, and a softer gel.

Table 2. Presents the Development of Modified Flour Products from Local Foods

<table>
<thead>
<tr>
<th>Type of Flour</th>
<th>Product</th>
<th>Modified Technology</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified swamp tuber flour and bamboo shoot flour</td>
<td>Coating flour of fried product</td>
<td>Fermentation (Lactobacillus casei)</td>
<td>[59]</td>
</tr>
<tr>
<td>Modified taro flour</td>
<td>Chicken meatballs</td>
<td>Heat Moisture Treatment</td>
<td>[61]</td>
</tr>
<tr>
<td>Modified corn flour</td>
<td></td>
<td>Fermentation (Lactobacillus Plantarum)</td>
<td>[17]</td>
</tr>
</tbody>
</table>
### 4 Conclusion

The lack of gluten affects the texture and sensory properties of products, various methods can be applied to improve product quality from modified flours. This review and the efforts of several studies suggest that modified flour technology can play an integral role in cost savings, encouraging local food utilization, encouraging local farmers, and improving farming systems. Limited reports regarding the nutritional and health benefits of products developed using modified flour suggest that more research is needed for validation purposes and possible commercialization. Information regarding possible adverse reactions to products from modified flour is lacking. However, adverse reactions may occur in some people, depending on their immune system. While consumers need to be aware of this, research efforts are needed to identify possible allergic reactions or toxicity that could be associated with products resulting from the application of modified flour.
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