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Unveiling the cultural significance and development of “*wajik*”, a traditional Javanese food

Ata Aditya Wardana^{1*} and R. Haryo Bimo Setiarto²

Abstract

Indonesia is the fourth most populous country in the world with a diverse array of traditional food, including main dishes, snacks, and indigenous beverages. The paper aims to explore the cultural significance, historical and philosophical perspectives, production, physicochemical properties, recent development studies, and the safety, shelf life and microbiological aspect of *wajik*, a traditional Javanese food. *Wajik* originated during the *Majapahit* era in Central and East Java and is still significant today in ceremonial events. *Wajik*, rooted in the Javanese phrase “*wani tumindak becik*”, symbolizes courageous pursuit of righteousness and reflects the unwavering commitment to virtuous actions, with its etymological link to diamond-shaped playing cards. *Wajik* is an officially recognized semi-wet snack made from glutinous rice, palm sugar, and coconut milk, with a distinctive texture and delightful, sweet taste, typically served as a leisure snack due to its parallelogram shape, semi-wet texture, and slight stickiness, requiring specific equipment and standardized ingredients for production. Some strategies have been developed to increase the quality, value added, and to prolong the shelf life of *wajik* through innovative packaging, food safety system implementation, and product reformulation.

Keywords Food culture, Javanese, Traditional food, Local wisdom, History

Introduction

Indonesia is the world’s fourth most populous country, with an estimated population of over 275 million as of 2022 [1]. The population of Indonesia is diverse, with over 300 ethnic groups and 652 local languages spoken [2]. The population is predominantly Muslim, with Islam being the majority religion. Other major religions include Christianity, Hinduism, and Buddhism. The country comprises more than 17,000 islands, with Java being the

most populous island and home to more than half of the country’s population.

The biodiversity of food types serves as an indicator of a nation’s cultural advancement. Traditional foods, rooted in local knowledge and wisdom, embody distinctive flavors embraced by specific communities [3]. Typically, these foods epitomize regional characteristics, cultural values, and indigenous culinary traditions, synergizing with the natural resources inherent to each locality [4]. Traditional foods intimately acquaint themselves with local phenomena, elucidating the developmental intricacies specific to a given area [5]. Consequently, traditional cuisine, enriched by its biological reservoirs, intertwines with customs, history, and religious convictions, amalgamating into a cohesive entity that resonates with society as an integral aspect of spiritual and communal life [3–5]. Beyond mere sustenance and health maintenance,

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food assumes significance in fostering the human-divine relationship and stands poised to bolster future tourism endeavors, thereby serving as a potential revenue stream for regional economies [3, 6].

The Javanese people have had a rich tradition of traditional food since time immemorial, encompassing main meals, snack markets, and traditional drinks. This has led Indonesian people to prefer consuming traditional food due to its deliciousness, healthiness, safety, and appropriateness, aligning with their beliefs, morals, and culture [4]. Traditional Javanese food is deeply influenced by the local agriculture and culinary practices of the people residing in Java, Indonesia [5]. Considering its diverse flavors, historical significance, and traditional roots, Javanese food remains a crucial component of the Javanese people's cultural identity. Additionally, the Javanese have a unique way of serving food, emphasizing communal meals where guests are invited to partake in a specific order of dishes, accompanied by prayers and rituals.

One of the important foods at a traditional Javanese event is *wajik* (Fig. 1). This traditional food holds significant value in the country's culture and history, reflecting the local traditions passed down from generation to generation. Made from sticky rice, this special food is a mandatory menu item, particularly at Javanese weddings. Despite its cultural importance, only few literatures pertaining to *wajik* found in international databases, including the study of the lipolytic bacteria causing rancidity of



Fig. 1 The appearance of *wajik*, a traditional Indonesian cake that is made from sticky rice blended with palm or brown sugar and coconut milk. The term "*wani tumindak becik*" in Javanese, from which *wajik* originates, represents the brave quest for goodness and exemplifies steadfast dedication to honorable deeds, with its etymological link to diamond-shaped playing cards

wajik [7] and problem solving in *wajik* production using Pareto distribution model [8]. This paper aims to explore the culture of *wajik* from historical and philosophical perspectives, production aspect, physicochemical properties, and recent development studies. Through an in-depth understanding of this traditional food, individuals can gain a profound understanding and appreciation of the country's culture and heritage. Furthermore, it can contribute to the preservation and promotion of traditional foods and local cuisines, which often face threats from globalization and food standardization.

History of *wajik*

The word "*wajik*" is certainly not unfamiliar to the people of Central and East Java, especially when it comes to food. *Wajik* is a kind of traditional cake made from glutinous rice mixed with palm or brown sugar and coconut milk. The mixture is then cut into diamond shape, as seen in Fig. 1. This type of food was first discovered during the Majapahit Era [9, 10].

Majapahit, which R. Wijaya established in the twelfth century, was the largest Hindu-Buddhist patterned kingdom that ever ruled in the Nusantara (the term for the entire Indonesian and surrounding's archipelago) [11, 12]. The Kingdom was pioneered by Raden Wijaya who control almost the entire archipelago until fifteenth century and had a life span of about 185 years heyday (1293–1478 AD) [13]. This kingdom reached the peak of its glory and succeeded in controlling various regions in the archipelago under the reign of King Hayam Wuruk and Mahapatih (vice regent), Gajah Mada, who ruled from 1350 to 1389 AD [14]. During the reign of Majapahit, the term Nusantara was understood as islands outside the center of the central government in Java, precisely in Mojokerto, East Java (Fig. 2). It covered Sumatra, the Malay Peninsula, Kalimantan, Sulawesi, Nusa Tenggara, Maluku, Papua, Tumasik (Singapore), and the Philippines. The presence of Majapahit in the Nusantara lasted until the fourteenth century [15]. Over almost 200 years, the kingdom left numerous cultural heritages, including buildings, customs, and arts. Furthermore, the community has preserved various relics, including a traditional meal that are still found today.

During the *Majapahit* era, *wajik* was considered as a type of food or snack [10, 16]. This was documented in the *serat Nawaruci*, a literary work in the ancient Javanese language that emerged during the *Majapahit* empire [10]. It is an ancient manuscript written on a *rontal* sheet containing an acculturative mystical culture [16]. In Javanese, "*ron*" means leaf, and "*ntal*" means *siwalan* (palm tree). They were strung together with threads into one that can be unfolded and can also be stacked [17]. It is also known as *Sang Hyang Tatwa Jnana*, was written

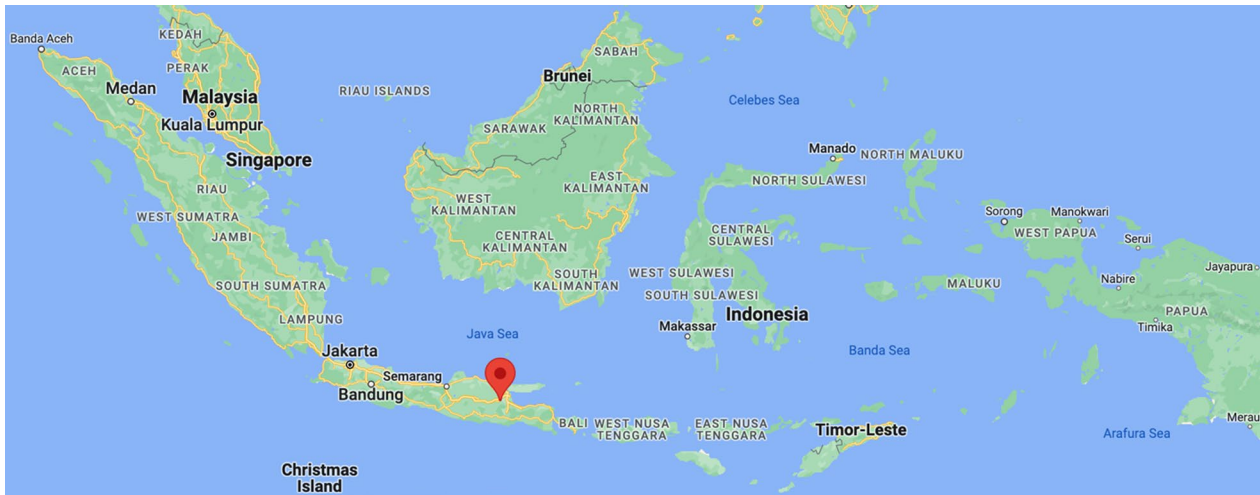


Fig. 2 The location of Mojokerto, the capital city of Majapahit Empire (retrieved from: <https://www.google.com/maps/place/Kota+Mojokerto,+Mergelo,+Kota+Mojokerto,+Jawa+Timur>). It was the original site where *wajik* was first discovered between twelfth and fourteenth centuries. The Majapahit Empire, the largest kingdom influenced by Hindu-Buddhist traditions, governed the entire Indonesian archipelago and its surrounding regions, known as Nusantara

between 1500 and 1619 AD by *empu Siwamurti*, as documented by Prijoehoetomo in 1934 (Fig. 3) [10]. *Empu* is a term for someone who has extraordinary expertise in the arts and culture. The *Nawaruci* book is a religious literary work influenced by Hindu mystical teachings [18–20]. The birth of the *Nawaruci* book coincided with

the spread and development of Islam among the Javanese people [21].

Wajik serves as a mandatory complement to the *gunungan* (mountain miniature) in the *tumplak wajik* event, a routine ceremonial and ritual performance in Yogyakarta Province (Fig. 4b), in addition to being a

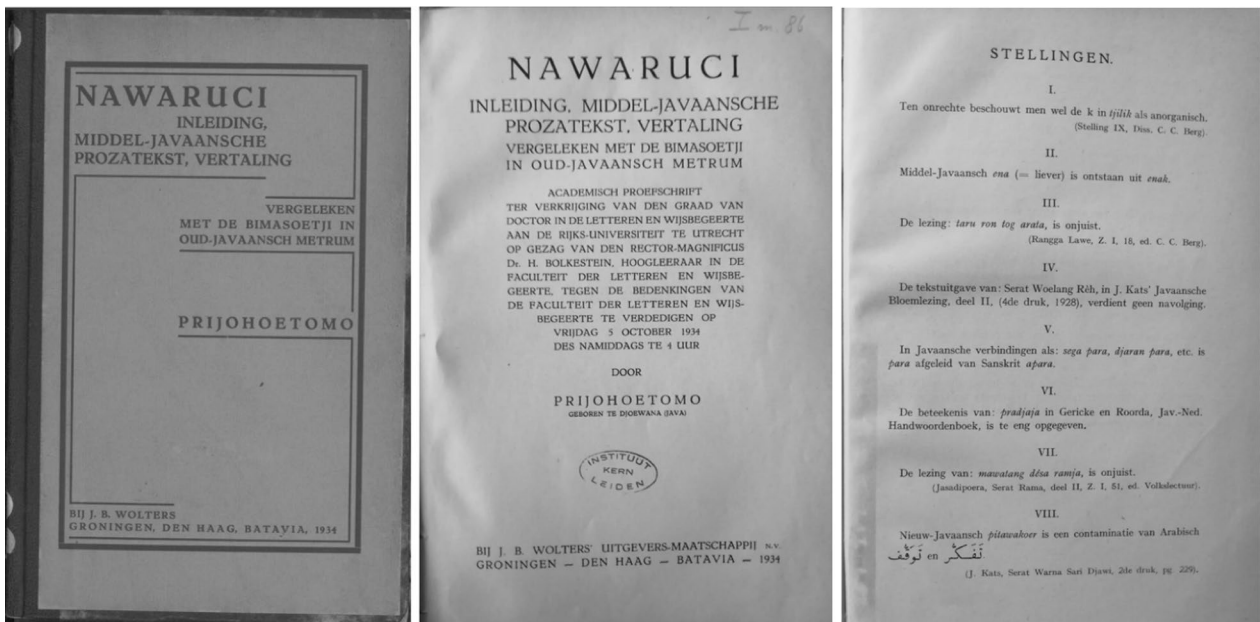


Fig. 3 The photograph of *Nawaruci* paper in dutch [10]. The original manuscript of *Nawaruci* was analyzed by Prijoehoetomo in 1934 as part of his dissertation at a university in the Netherlands. This document serves as the sole translation and provides a comprehensive discussion, enabling it to be understood by modern society



Fig. 4 The *wajik*-making scene on a large pot (a) and the *tumplak wajik* ceremony (b) (retrieved from: <https://pariwisata.jogjakota.go.id>, <https://tumpi.id/srah-srahan-dalam-pengantin-jawa/>). The ceremony involves stringing the *gunungan Estri*, which holds a distinctive feature, a basket of *wajik* arranged with layers of *tiwul* (a processed cassava food) serving as the foundation for the *mustaka gunungan* (crown)

common home meal. It symbolizes the initiation of a series of alms representations from the king of the Yogyakarta palace to the people, commemorating three significant Islamic occasions: *grebeg mulud* (the birth of the Prophet Muhammad), *grebeg syawal* (*Eid al-Fithr* day), and *grebeg besar* (*Eid al-Adha* day) [22, 23]. Unlike other areas on the island of Java, the traditional Javanese ceremonies are still widely held in Yogyakarta today to preserve cultural heritage. This is linked to Yogyakarta's historical significance as a cultural hub of the Islamic Mataram Kingdom from the 16–eighteenth centuries, led by descendants of Ki Ageng Pamanahan, a noble lineage tracing back to the rulers of Majapahit [24]. Following the fall of the Majapahit Kingdom around 1527, Islamic kingdoms such as Demak, Pajang, and later Islamic Mataram emerged on the island of Java [25, 26]. Javanese society's way of life was greatly influenced by the fusion of cultural heritage with Islamic teachings, including ceremonies including *tumplak wajik* [27]. This acculturation owes much to the efforts of religious figures, particularly Sunan Kalijaga, in spreading Islam throughout Java from the late 14–sixteenth centuries [28, 29].

Furthermore, *wajik* holds a compulsory role as a traditional Javanese wedding ceremony meal known as “*srah-srahan*” (Fig. 5). *Srah-srahan*, a prominent cultural event within Javanese traditions, involves the exchange of specific items from the groom to the bride, representing a binding symbol and a gesture of respect [30]. This ceremony takes place at the bride's residence, inviting neighbors, relatives, and extended family members to gather. As part of the groom's family's offerings,



Fig. 5 The photograph of *srah-srahan wajik*. *Srah-srahan* serves as a ceremonial wedding gift offered by the groom to the bride, representing the lasting aspiration for a resilient and everlasting union between the married couple

various foods including *jadah*, *wajik*, and *jenang* are presented to the prospective bride [31, 32].

Philosophy of *wajik*

Wajik, derived from the Javanese term “*wani tumindak becik*,” embodies the virtue of bravery in performing good deeds and seeking goodness [33]. This noble characteristic exemplifies unwavering commitment to righteous actions. The term *wajik* finds its etymological association with playing cards resembling diamonds, known as *wajik* in Javanese [33]. However, in the context of culinary traditions, *wajik* is a delectable treat made from a

blend of sticky and flavorful glutinous rice, infused with coconut milk and palm sugar, resulting in a delightful combination of sweetness, savoriness, and stickiness [5, 33]. The utilization of glutinous rice symbolizes the profound interconnectedness of brotherhood and friendship, while coconut milk, referred to as “*santen (sagedo paring pangapunten)*” in Javanese, symbolizes the aspiration for inner peace, encouraging individuals to embody forgiveness and compassion by readily forgiving others [34]. Moreover, palm sugar signifies the enduring hope that friendships and relationships fostered will forever remain sweet, harmonious, and peaceful [5].

Wajik serves as a traditional delicacy commonly enjoyed during joyous occasions, including weddings, traditional ceremonies, and expressions of gratitude. Furthermore, it holds great significance as a cherished souvenir when visiting various events such as *hajatan* (collective prayers), traditional gatherings, weddings, and more [22, 32]. In traditional festivities, *wajik* symbolizes the unity and indivisibility among community members and religious practitioners, signifying harmony [5]. During such occasions, the preparation of *wajik* involves a large-scale process, utilizing an oversized wok heated over a traditional stove, requiring the collaborative efforts of several individuals to ensure its successful production (Fig. 4a).

Wajik is an essential element in the wedding ceremony of Javanese traditional customs, symbolizing the enduring hope for a strong and everlasting marriage relationship between the couple. *Srah-srahan*, as a wedding gift presented by the groom to the bride, represents this significant meaning (Fig. 5) [35]. In its raw form, the sticky rice grains do not stick together. However, through the meticulous process of transforming it into *wajik*, the rice becomes a unified and stronger product, symbolizing the merging of the two families and the strengthening of their bond [36, 37]. The preparation of *wajik* requires considerable time, patience, and the collaborative effort of multiple individuals, serving as a valuable lesson for married couples to persevere in building and nurturing their household. The tradition of including *wajik* in wedding celebrations continues to be observed not only in rural areas but also in urban regions, particularly in East Java, Central Java, and Yogyakarta [38].

In the district of Musi Banyuasin, South Sumatra Province, the inclusion of *wajik* in a wedding procession signifies the groom's party creating a distinctive *wajik* cake as a symbol of “*ganti duduk*” (changing seats), signifying the bride's transition to the groom's household. Simultaneously, the bride's family also presents *wajik* as a gesture of *ganti duduk*, symbolizing the unification of the two extended families, and the groom's family welcoming the bride with honor and reverence [35]. The spread of

wajik from Java to Banyuasin is believed to be associated with the presence of the Sriwijaya Kingdom around the 6–twelfth centuries. The peak of the Sriwijaya Kingdom's glory began in the 8–ninth centuries under the leadership of King Balaputradewa [36]. According to the Nalanda inscription, Balaputradewa was the son of Samaratungga, the King of the Mataram Kuno Kingdom located in Java, from the lineage of the Syailendra Dynasty [37].

Wajik serves a dual role in Javanese culture, being utilized not only in ceremonial marriages but also as a crucial element in the *tumplak wajik* ceremony. This ritual, meaning the stacking of *wajik*, symbolizes the initial step in the creation of one of the seven *gunungan*, namely *gunungan putri*, *gunungan putra* (3), *gunungan gepak*, *gunungan darat*, and *gunungan pawuhan* [41]. While *wajik* outwardly represents a delectable combination of savory and sweet flavors, it carries profound symbolic meanings such as prosperity and brotherhood [42, 43].

Wajik production

Wajik is an officially recognized semi-wet snack, categorized as an intermediate moisture food, which is produced through the processing of glutinous rice, palm sugar, and coconut milk, with or without the inclusion of other food additives, according to SNI 01-4272-1996 [44]. Typically served as a leisure snack, *wajik* differs from other processed glutinous rice products like *jenang*, *wingko*, and *krasikan*, as *wajik* does not undergo flouring prior to preparation, resulting in a distinct texture. The notable advantage of *wajik* lies in their delightful and legitimate sweet taste, making them an ideal choice for snacks. Characteristically, *wajik* possess a parallelogram shape, semi-wet texture, and a slight stickiness due to the utilization of high-amylopectin glutinous rice [45]. Consequently, ordinary rice cannot be substituted for the glutinous rice raw material. The unique flavor of *wajik* is attributed to the presence of palm sugar and coconut milk. Typically, *wajik* exhibit a brown color derived from brown or palm sugar, although some variations have been innovated to incorporate food coloring and introduce vibrant hues. For a single production batch of *wajik*, the required equipment includes stoves, frying pans, wooden stirrers, spoons, basins, tea filters, and bamboo winnowing tools. The standardized formulation for one batch of *wajik* consists of 5 kg of glutinous rice, 5 L of coconut milk (obtained from 10 coconuts), 2 kg of palm sugar, 300 g of sugar, and 20 g of pandan leaves [46]. Alternatively, some recipes may employ only sugar or brown sugar instead of palm sugar, with the addition of food coloring.

The *wajik*-making process commences with the initial step of soaking glutinous rice for 2–4 h and subsequent draining, as depicted in Fig. 6. The soaked glutinous rice



Fig. 6 Flowchart of *wajik* preparation. (1) Sticky rice soaking, and (2) steaming; (3) coconut milk and pandan leaves mixing and (4) brown sugar adding; (5) all ingredients mixing, (6) cooling and printing, (7) serving in the diamond shape

is then steamed for 30 min. Coconut milk is prepared by combining it with brown or palm sugar, pandan leaves, and refined sugar or salt (optional), and cooked until it reaches a boiling point. The resulting mixture is subsequently strained to eliminate any impurities, particularly those originating from the palm or brown sugar. Furthermore, the coconut milk and sugar concoction are cooked over low heat, and the glutinous rice is introduced, requiring continuous stirring with a large wooden spoon. The dough is stirred diligently for a period of 3–4 h until it assumes a brown and oily consistency. The dough is then poured on the tray and left to cool. During the cooking process, the formation of a distinctive flavor emerges as the coconut milk is cooked, resulting in a remarkable aroma [47]. It is promptly removed from heat and allowed to cool slightly, followed by the subsequent steps of molding, cutting, and wrapping in banana leaves or plastic [48, 49]. To ensure the production of high-quality and delicious *wajik*, it is recommended to utilize top-grade glutinous rice with intact grains, free from mixing with regular rice, and soaked for several hours to achieve a fluffier texture upon steaming. Additionally, the use of fresh coconut milk extracted from grated coconut is essential for attaining a natural savory flavor.

In certain regions, particularly West Java (Sundanese), the process is conducted by arranging the ingredients in dried corn husk and placing them on a bamboo window to dry under the scorching sun. The final product is known by a slightly different name in comparison to *wajik* (Javanese), referred to as "*wajit*" (Sundanese). Another term is also utilized in the Bengkulu province area, namely "*bajik*," and in the West Sumatera area, called "*simanih*" [50]. Although the names vary by region,

the fundamental ingredients and production methods for these products are similar. The only distinction lies in the packaging of *wajit*, which employs creamy white corn husks. Moreover, *wajit* is typically produced for commercial purposes, usually as a distinctive souvenir of Bandung city, West Java. Meanwhile, *wajik*, *bajik*, or *simanih* are produced for traditional events and important rituals in rural areas [41, 42].

Physicochemical and organoleptic properties of *wajik*

Wajik has a moisture content of around 10–40% and a water activity (a_w) of 0.65–0.9 [51]. The standard moisture content of *wajik* is no more than 30% and a sugar content (calculated as sucrose) of no less than 15% [44]. Generally, *wajik* has a sweet, and savory taste that comes from a mixture of palm sugar and coconut milk. In addition, it is diamond in shape, and has a semi-wet and sticky texture due to the high amylopectin content of glutinous rice comparing with amylose fraction, with ratio 80–90% (amylopectin): 2–10% (amylose) [45, 52]. Glutinous rice has a white color and opaque appearance due to its high amylopectin starch content, resulting in a cohesive texture. The appearance of a brown color of *wajik*, beside caramelization and the maillard reaction, is mainly due to the presence of palm sugar. *Wajik* has been standardized by Indonesia national standard (BSN), stated in the document of SNI 01-4272-1996 [44]. The standard characteristic of *wajik* is stated in Table 1.

The incorporation of either palm or brown sugar during the preparation process of *wajik* plays a significant role in shaping its physicochemical properties. Palm sugar, derived from the sap of the palm tree (*Arenga*

Table 1 Standard of quality requirements of *wajik*

No.	Tested parameters	Unit	Limit
1	Organoleptic:		
1.1	Aroma	–	Normal
1.2	Color	–	Normal
1.3	Taste	–	Sweet typical <i>wajik</i>
2	Foreign object	–	Not apparently
3	Water	%	Maximum 30.00
4	Sugar (counted as sucrose)	%	Minimum 15.00
5	Free fatty acid (counted as lauric acid)	%	Maximum 0.10
6	Ash content	%	Maximum 1.50
7	Sweeteners	–	Negative
8	Preservatives	mg/kg	Permitted amount
9	Coloring	–	Permitted amount
10	Metal contamination:		
10.1	Cu	mg/kg	Maximum 10.00
10.2	Pb	mg/kg	Maximum 1.00
11	Microbial contaminants (mold and yeast)	cfu/g	Maximum 1×10^2

Source: Standard Nasional Indonesia (SNI) 01-4272-1996 (<https://pesta.bsn.go.id/produk/detail/4689-sni01-4272-1996> SNI 01-4272-1996)

pinnata Merr), possesses a distinct, bright yellowish color, while brown sugar is derived from the sap of the coconut tree (*Cocos nucifera* L.) [53]. The utilization of these particular sugars in the *wajik*-making process aims to impart a sweet taste and a characteristic brown hue. This is achieved through chemical reactions known as caramelization and the Maillard reaction, resulting in the formation of a unique brown color, flavor, and taste [54, 55]. Unlike the enzymatic browning observed in fruits and vegetables, the non-enzymatic browning in semi-wet foods, specifically *wajik*, imparts distinct visual and sensory attributes. When sugar is subjected to heat over its melting point, typically at 170 °C, caramelization occurs [56]. Furthermore, semi-wet foods contain proteins in conjunction with sugar. Under high-temperature conditions, this combination facilitates the Maillard reactions between reducing sugars and primary amine groups [54, 57]. In the case of *wajik*, these reactions profoundly influence the development of the final product's color, leading to its distinctive brown shade without the need for additional coloring agents [47].

Sugar undergoes decomposition into simpler compounds during the cooking and processing process. The resultant sugar decomposition leads to the formation of reducing monosaccharide sugars such as glucose and fructose [58], impacting the flavor profile of *wajik*. Nevertheless, the reduced sugars generated do not pose any food safety concerns for *wajik*; rather, they solely influence the organoleptic taste of *wajik*, predominantly

rendering them sweeter [51]. Additionally, the sugar content plays a crucial role in determining the texture of *wajik*. Higher sugar content results in a harder texture [59, 60], and may inhibit the growth of food spoilage microbes, particularly bacteria [61]. The high sugar content binds the water present in the food, consequently reducing the a_w value [61].

Other ingredients are also responsible to the final properties of *wajik*. Good coconut milk produces a sweet and savory taste, aroma and texture. Coconut milk suitable for *wajik* comes from old coconuts with thick flesh [46]. The coconut milk roles as an oil source to make the unique oily of *wajik* surface. Using fresh coconut milk extracted from coconuts results in better taste and quality than instant coconut milk. It is important to cook coconut milk over low heat and constantly stir preventing the occurrence of off flavor, undesirable aroma, and color [62, 63]. Moreover, over heating process results coagulation to be two separated phase due to the breaking of emulsion system [64]. Overusing coconut milk can result in *wajik* that are excessively oily and prone to rancidity [65]. The use of pandan leaves serve the function of providing a distinctive fragrant aroma, which comes from the chemical compound 2-acetyl-1-pyrroline [66, 67]. Furthermore, the addition of salt and sugar aim to enhance taste and act as a preservative because of the free water binding ability [68].

The *wajik* should undergo cooking process until moderately firm texture to ensure a longer shelf. In some areas, shallots are also added during the production process. The presence of essential oils in shallots gives *wajik* a distinctive aroma, savory taste, and enhances appetite. Additionally, these essential oils (cycloaliin, methylaliin, dihydroaliin, flavon glycosides, quercetin, saponins, peptides, and phytohormones) serve as preservatives due to their bactericidal and fungicidal properties against certain bacteria and fungi [69].

Recent studies on *wajik*

The summary of recent studies on *wajik* is presented in Table 2. Product competition no longer relies solely on superior product quality, but also on the packaging that encompasses the product. One strategy to address this competition is through packaging design. It is expected that good packaging should prioritize product safety, provide information, and have visual appeal. The art paper ivory and wax paper were identified as the best candidates for secondary and primary packaging, respectively, for *wajik* [70]. These concepts were able to maintain the quality of the *wajik* by preventing hardness, moldiness, and rancidity reactions. Moreover, it offered economic advantages, making the selling price suitable for consumers in lower income brackets. The value added

Table 2 Summary of recent studies on *wajik*

No	Investigation aspect	Findings	Reference
1	Identification of lipolytic bacteria	Discovered gram-negative bacteria with spherical and rods shape Indicated similarity to <i>Acinetobacter</i> and <i>Pseudomonas</i>	Susilowati et al. [7]
2	Application of food safety management system	Implementation of Hazard Analysis Critical Control Point (HACCP) system Cooking and Packaging steps were critical control points	Zakaria [51]
3	Packaging design through the quality function deployment method	Art paper ivory type was the best choice for secondary packaging Wax paper was the best for primary packaging	Setiawati and Mulyati [70]
4	Increasing of added value of <i>wajit</i> through innovative packaging	The use of corn husk combined with polypropylene film and folding carton could improve the added value and shelf life	Pudjiastuti and Herman [71]
5	New packaging with chitosan-PVA film instead of synthetic plastic	Inhibited free fatty acid production Prolonged the shelf life until day 10	Fitria et al. [72]
6	Identification of contaminant molds	Found 55% of contaminant samples by <i>Aspergillus</i> spp.	Maryatin [74]
7	Nutritional characterization on <i>wajik</i> produced in Bengkulu area	The nutritional properties with 3.67% protein, 5.45% fat, and 22.54% carbohydrate	Yunita and Nur'aini [75]
8	Innovative formulation with the addition of jackfruit and its seeds	Improved the sensory characteristics The panelist (50%) liked the developed <i>wajik</i>	Miftahul et al. [76]
9	Modification of ingredients, chocolate on physical and sensory properties	Affected color difference (delta E) Improved cocoa flavor, bitterness, oiliness, and overall likeness	Darajah [77]
10	Modification of steaming time on physical and sensory properties	Decreased texture characteristic (hardness) Reduced product likeness value	Darajah [77]
11	Application of oil paper and edible film from tapioca	Oil paper packaging had longer shelf life comparing with edible film based on sensory test and thiobarbituric acid (TBA) value	Novitasari et al. [78]

and extended the shelf life of *wajit* were increased by redesigning its packaging using corn husk as the primary packaging, combined with polypropylene and folding carton [71]. The findings of their study served as a model for enhancing the value of *wajik* in small-scale industries in other areas of Indonesia. Additionally, innovative edible film and active packaging to inhibit the rancidity reaction in *wajik* have been developed [72]. The use of edible film is gaining attention due to its biocompatibility, non-toxicity, non-polluting nature, and its ability to act as a barrier to mass transfer (including water vapor, oxygen, and dissolved substances), while also being cost-effective [73]. Chitosan and polyvinyl alcohol (PVA) have been selected as coverings for *wajik*, significantly influenced the properties of *wajik* by reducing the production of free fatty acids [72].

To enhance the production and sales of *wajik* products with added value, a systematic strategy must be devised. In today's market, competition extends beyond product quality to include packaging design. Therefore, one of effective approaches to tackle this competition is through thoughtful packaging design. Effective packaging should prioritize product safety, provide information, and possess visual appeal. Quality Function Deployment (QFD) is a method utilized to tailor traditional *wajik* food

packaging to meet customer preferences [70]. The QFD involves a structured process of identifying customer needs and translating them into technical requirements comprehensible to all levels of the organization. QFD emphasizes early customer involvement in the product development process, recognizing that even a flawless product may not satisfy customers without their input [70]. The QFD process employs a matrix to translate consumer needs throughout planning and production stages, comprising four key stages including product planning, component planning, process planning, and production planning. Each stage contributes to aligning product characteristics with customer desires, from initial planning to production control [70].

Generally, *wajik* is produced by home industries; therefore, there are limited opportunities for innovation to enhance its quality and safety. Furthermore, their products do not comply with the Indonesian National Standard (SNI) [44]. The variability in water content of *wajik* is evident, often surpassing the maximum limit of 30%, thereby leading to accelerated food spoilage, deviations in taste profile, and potential health hazards [51]. To achieve high-quality *wajik* and meet the required standard, it is essential to implement thorough supervision and control at every stage of the production process, starting

from the raw material acquisition until the product is ready for market. Hence, it is necessary to implement the HACCP concept, which involves analyzing potential hazards and risks at each production stage, with the goal of minimizing or eliminating contaminants present in the *wajik* product [51].

Studies related to material reformulation and modification of the *wajik*-making process have been developed in the last decade. Jackfruit seeds have been reported as an alternative to glutinous rice in the manufacture of *wajik*, which contains 83.73% amylopectin and 16.23% amylose [76]. Additionally, the incorporation of jackfruit pulp into the *wajik* dough can serve as a new flavor variant and has been organoleptically accepted by consumers [76]. *Wajik* innovation, involving the addition of processed cocoa products, has been conducted with concentration levels ranging from 7.5 to 27.5% and a steaming time between 30 and 50 min [77]. The findings revealed that an increase in the concentration of chocolate paste led to a noticeable difference in the color of the *wajik*, and a longer steaming time for the glutinous rice resulted in a decrease in the texture value of the *wajik*. Overall, the formula and process preferred by the panelists involved a chocolate paste concentration of 27.5% and a steaming time of 40 min [77]. Apart from utilizing jackfruit seeds (waste) as a substitute for sticky rice, product development is conducted for commercial purposes [76, 77]. Manufacturers need to enhance the marketability of *wajik* products, as consumer interest tends to diminish over time. Nonetheless, the innovations undertaken do not diminish the significance of the *wajik* philosophy and the local wisdom. Authentic *wajik* are still frequently encountered, particularly at traditional community events and ceremonies. For certain purposes, local people have modified the raw materials and production process to achieve specific desired characteristics in the final product. *Wajik* has been transformed into various flavors, shapes, and colors, and the product names have been modified based on their visual appearance, such as "*wajik pandan*", "*wajik gula pasir*", "*wajik bunga telang*", "*wajik dua rasa*", "*wajik mawar*", "*wajik kemerdekaan*", and more, as depicted in Fig. 7.

Safety, shelf life and microbiological aspect

The tropical climate of Indonesia, with humidity levels ranging from 54 to 98% and temperatures from 19 to 33 °C, creates favorable conditions for the growth of microorganisms, while posing unfavorable environmental conditions for *wajik* [7]. The water content of semi-wet food products, ranged from 10 to 40%, and the a_w level of 0.65–0.90 contribute to the limited shelf life of *wajik* (2–3 days) in room temperature (27–28 °C). Additionally, contamination may be occurred through raw materials, production process, type of packaging used, storage, and food additives [74]. Microbial spoilage can be identified by the presence of yellow or white spots and cotton-like colonies on the surface of the *wajik*, visually observed after the 7 days of storage at room temperature. The texture of the *wajik* may become slimy, and an alcohol-like aroma is appeared as a consequence of the biodegradation (breakdown of organic compounds by microbial activity involving a series of enzymatic activities) of complex compounds into simpler ones [7].

Food safety is essential for ensuring good nutrition and health. It encompasses protection against biological, chemical, and physical contaminants that could pose risks to human health. Proper storage conditions for raw materials used in making *wajik* are crucial to prevent fungal contamination. Airborne contaminants, like *Aspergillus* spores, can easily infiltrate food products, posing health hazards [51]. The previous study highlighted contamination of *wajik* products with *Aspergillus* spp., emphasizing the importance of ensuring food safety for consumers [74]. Consumption of fungus-contaminated *wajik* can lead to various health issues, including poisoning due to aflatoxins produced by *Aspergillus flavus*. Aflatoxins B1 and B2, known for their high toxicity, can cause severe illnesses such as liver cancer and central nervous system disorders, and can even be lethal. *Aspergillus flavus* thrives in diverse environments, including substrates like *wajik*, due to factors like humidity, temperature, and pH. Indonesia's tropical climate, characterized by high humidity levels



Fig. 7 The visual appearance of modified wajik: (1) *pandan* (pandanus); (2) *gula pasir* (sugar); (3) *bunga telang* (butterfly pea); (4) *dua rasa* (two flavors); (5) *mawar* (rose); (6) *wajik kemerdekaan* (Independence Day), symbolizing the flag of Republic Indonesia, red and white. Retrieved from: <https://www.brilio.net/ragam/11-resep-aneka-wajik-ketan-manis-legit-dan-cocok-untuk-hantaran-210716t.html>

and elevated temperatures, provides conducive conditions for fungal growth, making food safety measures imperative [74].

Earlier study on the 20 *wajik* samples from 5 markets revealed that 55% of the samples were contaminated with the fungus *Aspergillus* sp. *Aspergillus* sp. is known to grow as saprobes in various organic materials, including bread, processed meat, rice grains, nuts, and food made from rice or sticky rice, as well as wood [79, 80]. Another report investigated the lipolytic bacteria isolated from Indonesian *wajik* with rancidity [7]. These bacteria were identified based on colony morphology, cell morphology, and the sequences of the 16S rRNA gene. The results indicated the presence of 7 lipolytic bacteria out of 52 isolates, all of which were Gram-negative, with spherical and rod-shaped cells. Four of the isolates showed a 97–98% similarity to *Acinetobacter*, while one isolate showed a 96% similarity to *Pseudomonas* [7].

The shelf life of *wajik* varies depending on several factors, including the materials used, storage method, and environmental temperature. *Wajik* generally have a shelf life of 3–12 days stored in an airtight container in the refrigerator at a temperature below 4 °C and shelf life of 2–3 days in room temperature (27–28 °C) [44, 46]. At freezer temperatures, it can extend the shelf life up to 2–3 months [44]. Consuming homemade *wajik* for a reasonable period (around 2–3 days) is crucial to reducing the risk of foodborne illness. If there are spoilage indications, such as spoilage fungi and bacteria, an unusual odor, or a slimy texture, *wajik* product should be discarded immediately [44, 46].

Several methods can be employed to extend the shelf life of *wajik*. One of them is the use of food additives, preservatives, in compliance with regulations. Adding a minimum of 40% sugar can also serve as an alternative to prolong the shelf life of *wajik*. Previous studies have reported that similar products (*jenang saban*), with a 40% increase in sugar content and packaged in sealed plastic packaging, were able to extend the product's shelf life up to 14 days [81]. The most recommended method is the utilization of natural antimicrobials such as bacteriocins. This technique has the least impact on the physicochemical and sensory properties of *wajik*, including health concerns. Bacteriocins can be natural preservatives to extend the shelf life of *wajik* by inhibiting the growth of pathogenic bacteria [82]. Bacteriocins are produced by a group of lactic acid bacteria (LAB), which are bactericidal against gram-positive and gram-negative bacteria. Some of the advantages of bacteriocins include safe for intestinal microflora because digestive tract enzymes quickly digest them, non-toxic and easily degraded by human proteolytic enzymes, and stable over pH and temperature [82, 83].

It is imperative to implement a robust food safety system to ensure the production of safe *wajik*. Quality control procedures are implemented to proactively mitigate potential quality deviations. The primary objective of quality control is to identify and rectify deviations, employing corrective and preventive measures [75, 76]. Comprehensive control measures should be implemented at each stage of the production process to prevent deviations. The cornerstone of the HACCP system lies in the anticipation and identification of hazards, with a focus on preventive measures rather than relying solely on end-product testing. While HACCP does not provide an absolute guarantee of food safety, it is designed to minimize the risks associated with food safety hazards. Additionally, the system serves to safeguard both raw materials and production processes against potential contamination hazards [77, 78].

The critical control point (CCP) established for *wajik* and similar products such as *jenang*, *wingko*, and *krasikan* are found in the raw material acceptance, namely sticky rice, palm sugar, and coconut. Savitri (2012) documented that the hazards in sticky rice include the presence of stones, sand (physical hazards), and pesticide residues (chemical hazards) [84]. The presence of microbial toxins from mold also poses a potential hazard to sticky rice and coconut, besides the risk of non-food grade preservatives contained in palm sugar. Apart from raw materials, CCP also applies to the cooking process. During cooking, there is a potential risk of physical contamination from coconut fibers and hair, as well as biological contamination from workers and equipment used. At the end of production, molding, and packaging is also CCP (physical) originating from dust, hair, and nail, as there are no further stages after this to eliminate these hazards [51, 84].

Conclusion

Wajik, a traditional food, is crafted from a blend of glutinous rice, palm sugar, and coconut milk. Its etymology stems from the Javanese lexicon, symbolizing the pursuit of moral rectitude and virtuous deeds. Historically noted in the Majapahit era as a meal, as documented in *the serat Nawaruci*. *Wajik* typically has a moisture content ranging from 10 to 40% and a water activity level between 0.65 and 0.9. Characterized by its diamond shape and a semi-wet, sticky texture attributed to the abundant amylopectin in glutinous rice. Given the limited scope for innovation within its traditional production methods, the implementation of HACCP system becomes imperative to achieve the standards of quality and safety. *Wajik* has undergone diversification in flavor, shape, and color over time.

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Author contributions

All authors (Ata Aditya Wardana and R. Haryo Bimo Setiarto) had equal contributions as the main contributors to this manuscript paper. Ata Aditya Wardana contributed to conceptualization (lead); visualization (lead); and writing—original draft (lead). R Haryo Bimo Setiarto contributed to conceptualization (lead) and writing—original draft (lead).

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Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

All the authors have read and approved the content of this manuscript for a publication, including the use of photos. The author must confirm that there is no problem with the copyright of the retrieved figures. In particular, please check whether the people in Fig. 4 have been agreed to be published.

Competing interests

The authors declare no competing interests.

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