

REVIEW ARTICLE

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The development and quality of jackfruit-based ethnic food, gudeg, from Indonesia

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Abstract

Gudeg is one of the Indonesian foods that are identical with the city of Yogyakarta. It has a long history and development, which is closely related to the history of Yogyakarta and Surakarta. However, it is currently known as a Yogyakarta specialty. Based on raw materials and packaging, it is divided into many kinds during the development process. The type of raw material used in producing gudeg is divided into two, jackfruit and *manggar*, while based on the processing method, it consists of wet and dry. Presently, it is marketed in various packages, including *kendil*, *besek*, boxed and canned gudeg. Research on the nutritional content and functional properties of gudeg has been carried out, although it is still limited to the macronutrient content, while for the functional properties only the fiber content. This research has mostly been done on gudeg jackfruit than on manggar gudeg. Therefore, this study focuses on the history, processing, packaging, nutritional value and sensory properties of gudeg. This shows that product information is an important factor related to consumers' perception of gudeg due to the fact they normally consider the sensory aspects, tradition, convenience and ease of cooking in selecting traditional foods.

Keywords: Culture, Gudeg, Indonesian cuisine, Jackfruit, Traditional food

Introduction

Young jackfruit (*gori*) is the main raw material used in producing gudeg. It is popular in various regions of Indonesia, in Sumatera, especially Minangkabau and is used as jackfruit curry, while in West Java it is cooked into *sayur asam*. In Central Java, young jackfruit is cooked into variety of dishes, such as *sayur lodeh* (soup with vegetables and coconut milk), *sayur megana* (chopped young jackfruit and grated coconut with certain spices), *oseng-oseng gori* (quickly cooked young jackfruit using less oil) and *jangan gori* (young jackfruit vegetable). The flower heads of the fruit (*babal* or *tongtolang*) are used as ingredients for salad (*rujak*), and food made from fruit

is sometimes accompanied by sliced vegetables (mashed and so on), then given a seasoning consisting of tamarind, sugar, chili, and so on, especially in Jakarta and West Java [1]. Gudeg is a traditional Indonesian food that is typical of the city of Yogyakarta. It has the basic ingredients present in the young jackfruit, cooked with spices and served with rice, eggs, chicken, tofu, *sambal krecek* and sprinkled with *areh* (savory coconut milk) [2]. Furthermore, it is generally stored under room conditions ($\pm 25^\circ\text{C}$) and presents a shelf life ranging between 2 and 3 days. As a traditional food, its flavor depends on the raw material, number of constituent components and preservation. The raw materials of gudeg come from nature native Indonesia with added spices and are cooked to produce a special taste [3].

Gudeg is indeed very special, where the food is well known throughout Indonesia and even abroad. It is generally known as gudeg Jogja, because in Yogyakarta there

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are many sellers or restaurants that specialize in its sales. Furthermore, it has a delicious taste, which makes tourists addicted and want to come back to visit Yogyakarta [4]. This is the reason why gudeg's image is closely related to Yogyakarta. Therefore, it is in high demand by domestic and foreign tourists as a traditional Indonesian food. The traditional Indonesian food is authentic Indonesian food that is made, processed using local ingredients with various processing methods and has local characteristics. It is usually consumed by several generations according to taste, does not conflict with religion and community beliefs and is made from food ingredients and spices available in the local area [5]. Furthermore, it is distinguished and recognized because of its relationship with a particular region or country [6].

Gudeg has developed in line with the history of Yogyakarta and is further considered as the authentic food and culinary origin of Yogyakarta. Therefore, it became a culinary icon of the community without any further questions, both by the people and immigrants. Likewise, it is written in many media that gudeg is a typical Yogyakarta food [7]. This was influenced by environmental and historical conditions, which affected the values that develop in gudeg itself. In addition, gudeg as a typical Yogyakarta culinary is associated with the local economy and it is hoped that the people's penchant for traditional culinary increases [5]. This is because culinary tourism is currently a type of tourism that affects the development of an area [8]. The concept of this type of tourism is not always luxurious and exclusive, but emphasizes experience, and therefore, the luxury aspect of the restaurant and completeness of the type of food or drink is not really considered. Usually, tourists not only enjoy the local panorama, but the food as well when visiting a place. In addition, food can be used as a souvenir to take home. Therefore, the culinary and souvenir business is an important aspect of Indonesian tourism [9]. In this role, gudeg is one of the foods that have an important position as an icon of Indonesian culinary tourism. It consists of several types, and even though it is famous for its characteristic in Yogyakarta, the city of Surakarta is a forerunner to its development.

Traditional foods, including gudeg, are currently not only enjoyed in their area of origin but also in almost all parts of the country [10]. This implies this food has not only directly introduced Javanese ethnicity but has an economic impact, especially in the Yogyakarta and Surakarta areas, due to the evolution of several restaurants selling the food. There are also Javanese royal palaces in these areas, and the presence of gudeg further strengthens the cultural atmosphere. Therefore, it is necessary to have a thorough discussion to ensure local and international communities understand the history, culture and

development of gudeg in order to reinforce its identity as traditional food, especially from Javanese ethnic culture.

Methods

The studies related to gudeg published in international journals have not been previously reviewed. Therefore, this present study focuses on reviewing past studies on the development and quality of gudeg using articles obtained from different databases such as Science Direct and Google Scholar, books, conference proceedings and other quality sources. These scientific and popular references were combined due to the lack of several scientific articles or journals on this concept. Moreover, the articles that focus specifically on the history and cooking methods of gudeg were selected over those that emphasize different recipes because their area of concentration is beyond the scope of this study. It is expected that this review be used to research and develop gudeg as a traditional food from Indonesia.

A short history of gudeg

According to Priyatmoko [11], gudeg comes from the word *hangudeg* which means cooking jackfruit with milk from coconut and melinjo (*Gnetum gnemon*) leaves using a large cauldron. In Serat Centhini, written by the poet of the Surakarta Hadiningrat Kingdom, it is stated that gudeg was not only developed in Yogyakarta. Furthermore, it was explained that during the Cebolang journey with the male santri to the Prince Tembayat house in Klaten and Endrasmara in Wonogiri, they encountered gudeg at the dining table. However, other foods were recorded in the journey, namely the type of *mannggar* gudeg (coconut flower) along with *kupat* (rice cake), chicken meat, soy powder and chicken eggs. Gudeg itself is served during the day when chatting and serves as a banquet from the host to his guests, while *mannggar* gudeg is served at breakfast [12]. Serat Centhini is Javanese literary work that contains various kinds of knowledge including history, education, geography, architecture, natural science, religion, Sufism, mystical, prediction, magic, immunity, *ilmu sirep*, criminal science, symbol, customs, ethics, psychology, fauna, flora, traditional medicine, art, sectionology and traditional food. It was written in January 1814 and completed in 1823 by Kyai Ngabehi Ranggasusastra, Kyai Ngabehi Yasadipura II and Kyai Ngabehi Sastradipura on the orders of Adipati Anom Amangkunegara III that was later made king of the Surakarta Kasunanan with the title Sunan Pakubuwana V [13]. Another source in Serat Jatno Hisworo explained that the ruler of the Kasunanan palace and his subordinates also tasted the *sepincuk* gudeg. Furthermore, Paku Buwana IX (1861–1893) reported that he bought gudeg and *nasi liwet* in the Baki area, Sukoharjo. The dish was

given to the *niyaga* party as an entertainer for the palace residents. In the era of Paku Buwana X (1893–1939), gudeg fans in the palace circles still continued. However, it was still developing at that time such as soup, *selat* and bread which were European menus. Paku Buwana X preferred local food, and therefore, he was called the Emperor of Java because he pushed Javanese culinary forward. It was seen that he often ordered palace women to cook gudeg *pakis*, *pecel lumbu*, *blenyik*, *gembrot* and *cabuk rambak*. Gudeg is the value of culinary knowledge passed down through the ages, and the method of processing requires patience and has a value in order not to waste the material given by Gusti Allah (God), namely in the form of *gori*, which makes it not just a technical matter [11]. *Gori* is the main ingredient in making gudeg, which is a young jackfruit whose seeds are not hard [14].

Furthermore, the development of gudeg in Yogyakarta, according to Gardjito and Eva [15], was influenced by the establishment of Gadjah Mada University (UGM) in 1949. The development of the gudeg production center, in the village of Gudeg Berek on Jalan Kaliurang, precisely in Karangasem area (north of Mataram ditch) started when the Gadjah Mada University campus moved from Kraton (Siti Hinggil) to Bulaksumur [14]. Gudeg is widely sold in the area around UGM, in order for a lot of students and employees to consume gudeg as their daily menu. The Berek area is the center of gudeg in Yogyakarta, and one of the reasons the people of this area sell gudeg is because at that time it had lots of jackfruit trees. Therefore, it was easy to obtain the raw material for young jackfruit “without capital,” namely by taking it from its own page [16]. This makes gudeg a traditional food, as one of the elements of culture and identity of the people of Yogyakarta which is adjusted to the available resources [17]. Traditional food is the identity of a tribe due to its relationship with the culture of the people in its nation or tribe [18]. The existence of gudeg is influenced by low prices, its ability to suit the Javanese tastes and easy-to-get raw materials. In addition, there are no rules or traditions that require it to be eaten at a certain time, and therefore, it is enjoyed at any time. Furthermore, the complementary ingredients for gudeg that are served in the morning or evening have no difference [19].

The cooking process for gudeg does not always have to be with new or fresh ingredients because it is warmable. Therefore, it may be cooked in large quantities and warmed when it is not eaten. Consequently, this food is always available at any time and due to these factors, it is maintainable. The process of cooking gudeg is similar to *bacem* technique and what is further added is *areh*. It is best known to be cooked with young jackfruit as its main ingredient. However, it may be served with complementary ingredients such as bamboo shoots, cassava or

manggar. Other ingredients that appear as complementary ingredients are chicken meat, duck egg, tofu, chili *tempe* and chili *krecek* [16]. Recipes and the procedure involved in its preparation are generally passed down from generation to generation. The distinctive taste is inseparable from the rich history of values that have been passed down from generation to generation. These values cannot be replaced easily, even with a modification process that ultimately tends toward commercialization and modernization, which has the potential to affect the loss of authenticity of this cuisine [20]. Therefore, this food culture is studied, shared and passed down from one generation to another and while some food lines have been refined and adapted, majority are still being implemented today [21]. Presently, the existence of gudeg is seen to have transformed into daily food that is easily found in restaurants or *warungs* (small traditional restaurants). The spread of influence through food as a manifestation culture has strengthened the concept of self-culture. Consequently, mutual influence between one culture and another cannot be avoided [22].

Making gudeg

Gudeg is prepared with young jackfruit as the main raw material. Initially, it was served with *areh* only, but while developing, it was served with other complementary ingredients such as cassava leaves, eggs, *tempe* fried chili sauce, *krecek* or chicken. Meanwhile, it is prepared using young jackfruit as the raw material [19]. *Areh* is a very thick sauce made from coconut milk mixed with *blondo* [23], which is a by-product of the coconut oil manufacturing process [24] and in the form of coconut oil dregs [23]. Gudeg has a characteristic sweet taste and brown color. Its brown color comes from teak leaves cooked with young jackfruit [19]. Traditionally, young teak leaves are used as food coloring [25], because they are natural pigment producers, namely anthocyanins [26]. The composition of the pigments present in young teak leaves include beta carotene, pheophytine, phelargonydine 3-glucoside, phelargonydine 3,7-diglucoside, chlorophyllide and two other unidentifiable pigments [26].

Preparation for gudeg production

The process of selecting jackfruit is an important step due to its subsequent effect on the gudeg to be produced. The jackfruit generally used to prepare gudeg is the bubur and salak variety despite the presence of several other varieties. Jackfruit pulp has a distinctive feature which is indicated by a thinner flesh surrounded by quite a lot of fiber. It is important to note that the bubur variety can be easily destroyed when processed into vegetables and this makes it more suitable for wet gudeg which does not take too long to prepare but usually crumb like mush when

used to prepare dry gudeg. Meanwhile, the salak variety has thick flesh with lesser fiber, hard or crunchy texture, and can be processed into the traditional food, especially the dry type because it does not break easily even when it is cooked for a long time or warmed several times [27].

The next step is to focus on the freshness of the young jackfruit and those considered to be fresh are usually sticky to touch and have a milky white color while those with brown and dull color are old or stale. Young jackfruits with small seeds and soft texture can also be selected due to the possibility of processing them into products with good taste and fluffier texture. Moreover, jackfruits normally have tough sap that can be removed by boiling before they are processed further and it is important to use fresh water when cooking because the boiled water has an astringent taste [28]. The nutritional content of ripe and young jackfruit according to the Indonesia Ministry of Health [29] is, therefore, presented in Table 1.

The processing of gudeg is complicated, because it takes quite a long time (one to two days) and needs to be completely cooked [19]. According to Rahayu [23], gudeg is divided into 2 based on its raw materials and these include the jackfruit and *manggar* gudeg.

Jackfruit gudeg

Gudeg is cooked using a cauldron or jug on a dry wood-fired stove. During the cooking process, it takes a long time for the spices to penetrate the young jackfruit pieces. The varieties of jackfruit in Indonesia normally used to prepare include bubur, pandan, salak, malaka, hutan, yellow, sukun, bulat, kunir and mini jackfruit according to Daud [30]. Furthermore, based on the cooking method, jackfruit gudeg is divided into two, namely dry and wet. The difference lies in the *areh* broth which is poured over the gudeg dish. For wet Gudeg, the areh sauce is usually

thinner and relatively not durable, while dry gudeg lasts longer and has a sweeter taste. The ingredients to prepare gudeg jackfruit have both Indonesian and English names [31] as indicated in Table 2.

According to Putra et al. [32], wet gudeg has a fairly high water content, while the dry form has relatively low water content. Gudeg is dried in the process of frying or stir-fried until it is dry enough, in order for the water content to be lower compared to the wet form. The process of making gudeg with the basic ingredients of young jackfruit is carried out by peeling the skin, removing the young jackfruit's core, reducing the size, boiling for one night or more (12–15 h) and continuously frying until it is dry enough (frying is carried out specifically for dry warm) [33]. The process of preparing wet and dry gudeg is presented in Fig. 1, while the difference between the wet and dry is summarized in Table 3.

The stirring process of gudeg is carried out occasionally and not too often to avoid breakage of the jackfruit [34]. In dry gudeg, the frying process aims to reduce the moisture content in order to make it more durable or last longer. The complementary ingredients such as *areh*, fried chili sauce, tofu, *tempe*, *krecek*, eggs and/or chicken are processed separately [32]. Due to the high water content, protein and fat, gudeg is prone to damage including discoloration, aroma and taste distortion and decreased nutritional value. In addition, it is usually marketed using baskets and kendil. Therefore, its shelf life is relatively short, which is around 48 h in room temperature [35].

Manggar gudeg

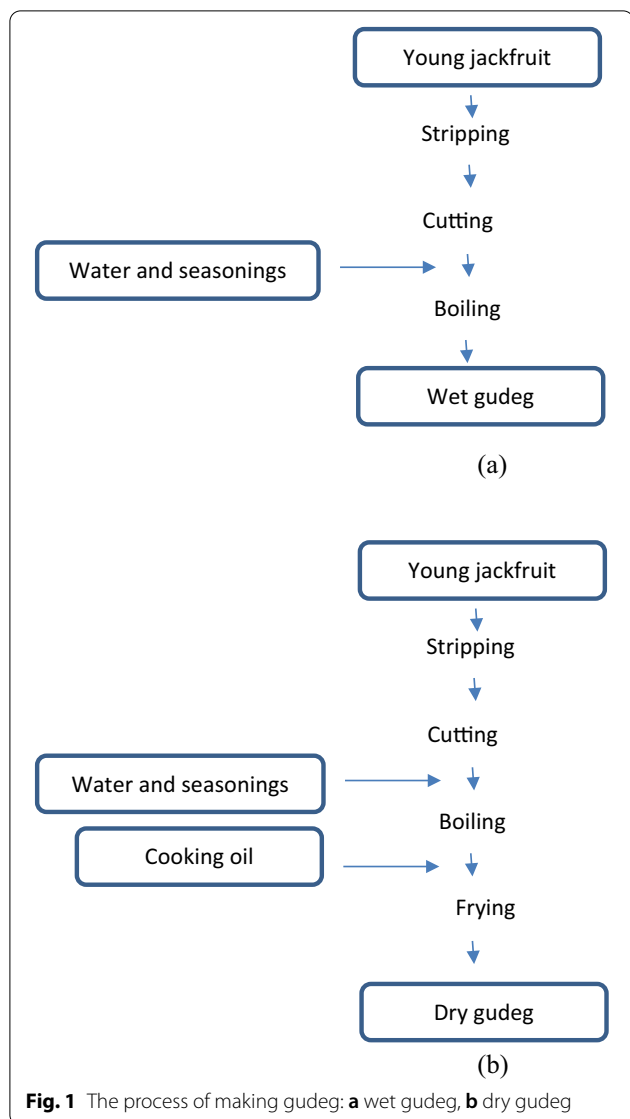
Manggar is used to make gudeg and is the youngest part of the whole coconut flower. *Manggar* gudeg has a denser, fibrous and thick texture. However, the taste is the same as jackfruit gudeg. Initially, it was only served

Table 1 The nutritional content of ripe and young jackfruit per 100 g

Nutrition	Ripe jackfruit	Young jackfruit
Energy (kcal)	106	51.00
Protein (g)	1.20	2.00
Fat (g)	0.30	0.40
Carbohydrate (g)	27.6	11.30
Calcium (mg)	20.00	45.00
Phosphorus (mg)	19.00	29.00
Iron (mg)	0.90	0.50
Vitamin A (SI)	330	25.00
Vitamin B ₁ (mg)	0.07	0.70
Vitamin C (mg)	7.00	9.00
Water content (%)	70.00	85.00

Table 2 The ingredients for making gudeg jackfruit

Indonesian name	English name	Quantity
Nangka muda	Young jackfruit	800 g
Daun jati	Teak leaves	6 leaves
Lengkuas	Galangal	2 cm
Daun salam	Bay leaves	3 leaves
Santan kelapa	Coconut milk	1000 mL
Air kelapa muda	Young coconut water	1000 mL
Bawang merah	Shallot	50 g
Bawang putih	Garlic	5 leaves
Kemiri	Candlenut	80 g
Ketumbar	Coriander	2.5 teaspoon
Gula merah	Brown sugar	275 g
Garam	Salt	2 teaspoon



in certain events, such as religious holidays, family parties and other special events. Over time, it became a daily dish for the people of Bantul, Yogyakarta. The process of making *manggar* gudeg is the same as jackfruit gudeg. Firstly, it is boiled to make it soft and further cooked with

mashed spices and coconut milk. The cooking process takes a long time, in order for the spices to be perfectly absorbed. The color of the cooked *manggar* changes from yellow to brown. Like jackfruit gudeg, it has complementary ingredients which include chicken eggs, *tempe* and tofu. *Manggar* gudeg is present in Bantul area, especially in Srandakan [13]. This is generally a wet type, and the difference between the jackfruit and manggar gudeg is presented in Fig. 2.

As a product of creativity, gudeg is too difficult to pick out to add a variety of flavors such as in noodle products, as there are noodles with *soto*, *rendang*, *satay* and *tengkleng* flavor. Therefore, there is currently no gudeg flavored noodles. The reason is that there is a hidden philosophical value behind the processing of gudeg which requires patience, making it not only delicious and full when eating. Moreover, there is a need for guidance to experience the flow of local Surakarta–Yogyakarta history as indicated in Fig. 3 and also to understand that traditional or ancient foods are not always inferior to Western foods considered to be modern [11]. In general, gudeg is made from young jackfruit, but there is a *ceker* gudeg, which is served with claws (chicken feet), giving it a different impression. The chicken feet (*ceker*) are cooked by boiling with coconut milk, in order to make them soft and tasty. The combination of gudeg and claws becomes even more delicious with the added *sambal goreng krecek* made from cow skin crackers. *Ceker* gudeg is eaten with rice or porridge [36] and served with *areh*, chicken, eggs or tofu [37]. Food diversity is not only influenced by foreign cultures, but also by existing natural resources. Furthermore, the development of a food is adapted to nature and culture [38].

Gudeg based on packaging

In the development of Gudeg, the wet form is generally consumed directly at a place or restaurant, while the dry form is usually brought as souvenirs for tourist [14]. According to Fibri and Frøst [39], there are currently 4 types of gudeg based on the type of packaging, namely *kendil*, *bese*, boxed and canned gudeg.

Kendil gudeg is usually served with chicken, *pindang* egg (brown-hard-boiled egg), *sambal krecek* (spicy stew

Table 3 The difference between wet and dry gudeg

Differences	Wet gudeg	Dry gudeg
Frying or stir-fried process	Without frying/string	With frying/string
Water content	High water content	Low water content
Shelf life (room temperature)	Around 24 h	Around 48 h
<i>areh</i> sauce	Thinner and relatively not durable	Lasts longer and has a sweeter taste
Food serving	Usually for dine in	Usually for dine in and take away (souvenir)



Fig. 2 The gudeg difference **a** jackfruit gudeg* **b** manggar gudeg**. *Jackfruit gudeg dish with rice, chicken, krecek, bacem eggs and tofu. (Additional dishes can be adjusted according to taste or according to the gudeg restaurant menu.) **Manggar gudeg dish with rice, krecek, bacem eggs and fried tempeh (additional dishes can be adjusted according to taste or according to the gudeg restaurant menu)

made of cow/buffalo skin cracker and coconut milk) and tofu—*tempe*. It is the version packed in earthenware (*kendil*), and in this packaging, gudeg has a shelf life of 2–3 days when stored in the refrigerator. According to Winata [40], it is an earthenware that serves as a container for storage and cooking food and liquids.

Besek gudeg is the complete dish packed in a bamboo woven basket (*besek*). Gudeg in this packaging has a shelf life of 2–3 days when stored in the refrigerator. Nurviana et al. [41] added that the *basek* in the past was used for food containers, provisions or food gifts. *Besek* is a container made of woven bamboo that forms a woven pattern. It has a basic square and rectangular shape having two parts, namely the bottom as

container and the top as cover [42]. The use of *besek* as gudeg packaging is more as cultural identity than the food itself. Furthermore, it does not affect the taste of gudeg, but gudeg without *besek* has a less identity, such as using plastic packaging or styrofoam, which reduces its image as traditional food. The impact will affect consumer perceptions of these foods [43]. *Besek* gudeg and *kendil* gudeg are used as packaging for souvenirs [24].

Boxed gudeg is the complete dish packed in a cardboard box. In this kind of packaging, gudeg has a shelf life of 1–2 days when stored in the refrigerator [44]. The use of boxes is usually for the purposes of ordering breakfast, lunch or recreation [24].

Canned gudeg is a complete traditional dish consisting of gudeg packed in a can and processed further by sterilization, in order to increase the shelf life to one year. The sterilization process aims to destroy microbes and pathogens, cooking products, providing the desired texture and taste. Therefore the sterilization process by heating should be carried out at a temperature high enough to destroy microbes, but not too high to prevent over cooking [45, 46]. Canned gudeg only contains jackfruit, while the complementary and side dishes are separately added.

The production process of canned gudeg should be carried out at the right temperature. The increase in the simulation results of the material temperature profile with matrix laboratory (MATLAB) indicates that the higher and longer the temperature and sterilization process, respectively, the darker the color of the product. This variation in treatment greatly affects the sterility value and texture of the resulting canned gudeg. The optimum treatment was obtained at a sterilization temperature of 121 °C for 20 min with a sterility and texture value of 4.32 min and 11.23 N/mm², respectively [47], with the sterility value observed to be influenced by several factors. It is also important to note that the value can be different when different gudeg samples are used. Meanwhile, the process involved in the production of canned gudeg is presented in Fig. 4 and this, according to Nurkimat et al. [48], includes several stages such as filling, exhausting and sterilizing.

The sample used for the experiment was Bu Tjitro’s canned gudeg which has 48.63 ± 1.37% gudeg, 22.77 ± 1.23% egg, 13.92 ± 1.42% krecek, 7.53 ± 0.53% tolo beans and 7.79 ± 0.65% chicken meat. The canning process was initiated by putting the material into a 72.63 × 53.04 mm (Ø × h) two-piece can with aluminize lacquer after which the exhausting pad process was conducted at 80–90 °C for 15 min to reach an initial temperature of 70 °C. The cans were closed with an “easy open end” type, sterilized at 121 °C for 20 min and cooled to 40 °C. The gudeg was later quarantined for 14 days.

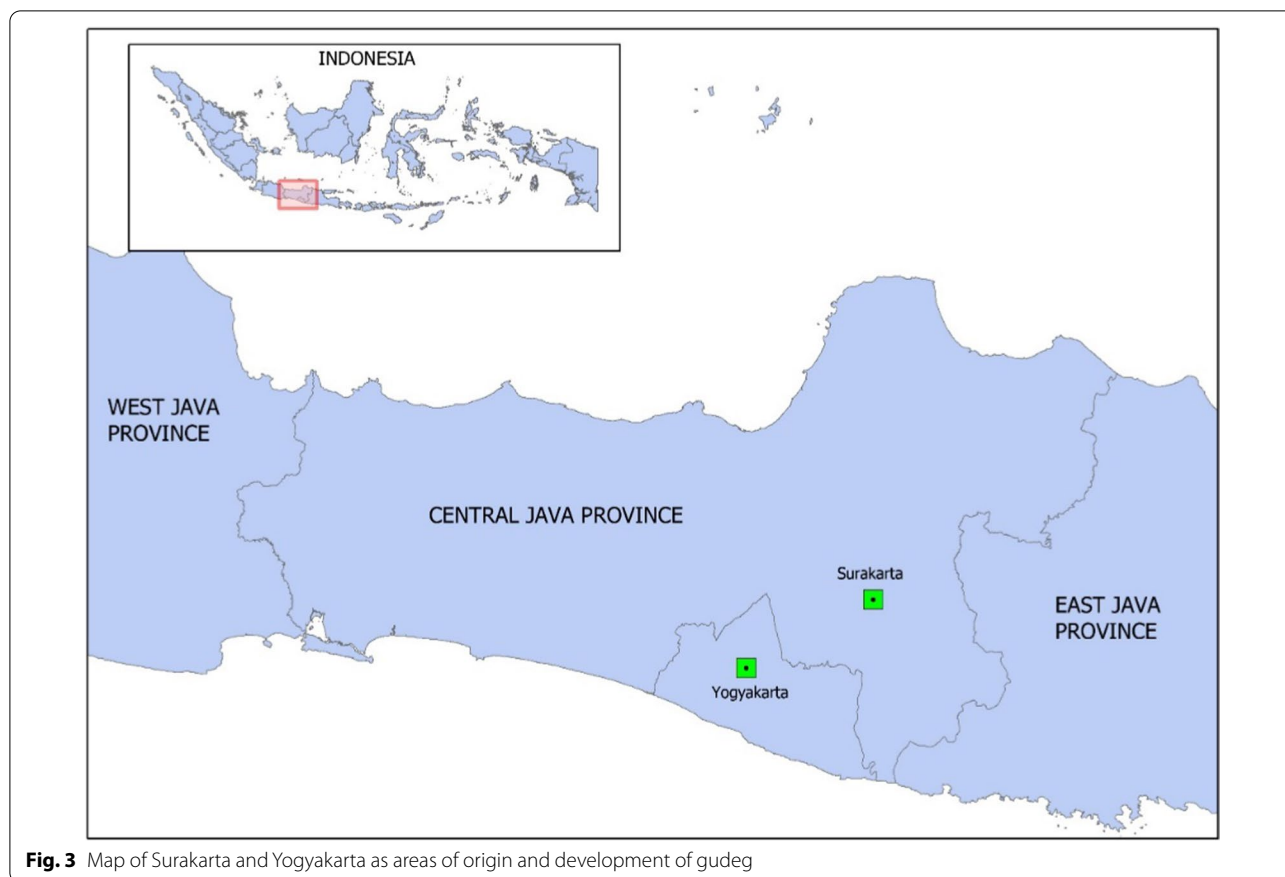


Fig. 3 Map of Surakarta and Yogyakarta as areas of origin and development of gudeg

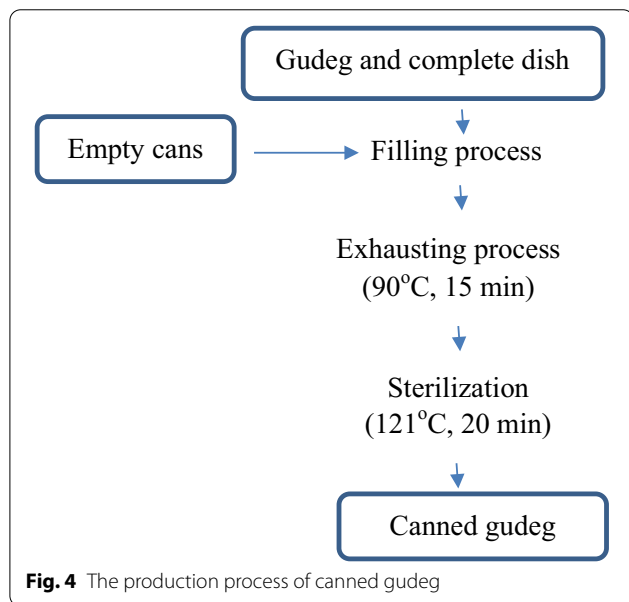


Fig. 4 The production process of canned gudeg

that attend cultural rituals. Here, gudeg is not used as a symbolic object for rituals and ceremonies, but as a support for social practices among the guests present. One of the non-roles of gudeg in ceremonies or rituals is related to the “absence” of symbolic meaning, or conversely, the absence of symbolic meaning in gudeg is related to its absence in any ceremony or ritual, starting from the absence of a role in this ritual, leading to a question about the relationship between gudeg and the center of government and the Yogyakarta tradition, namely the Kraton Yogyakarta. The many assumptions linking gudeg to the Kraton Yogyakarta are refuted by its absence (and also the use of young jackfruit as a food ingredient) in the Kraton Yogyakarta cooking recipe books. Furthermore, the separation of gudeg from its position as palace food makes it common people’s food [7].

Nutritional value and sensory properties of gudeg

Gudeg is one of the dishes normally served with other types of food due to its unpleasant taste when served alone, and this normally reduces the interest of consumers in the food [49]. This has led to the focus of previous studies on the nutritional content of gudeg, and its side dishes such as rice and the nutrition content of

In the tradition of Yogyakarta society, gudeg rarely has a special role in the cultural rituals that are held. However, it often appears as one of the offerings for guests

gudeg [50], canned gudeg [51] and *manggar* gudeg [52] were found to be different as indicated in Table 4 due to the variations in the basis of analysis and additional ingredients used. It is important to note that the gudeg jackfruit was analyzed with rice because it is considered one serving generally consumed by the people. Moreover, most of these studies focus only on the macronutrient content or proximate analysis of water, protein, fat, carbohydrates and ash content with only one found to study the fiber content. Triwitono et al. [53] studied the physical and chemical properties of dietary fiber as well as its potential physiological effects on gudeg and discovered that this food contains both insoluble and soluble dietary fibers at 41.3% db and 14.4% db, respectively. Furthermore, the fiber in gudeg has a water-holding capacity (WHC) of 3.6 g water/g fiber, a swelling ratio of 325% and a bulk volume of 1.3 ml/g, while the dry type was found to have 5 g of total fiber and 1.33 g of water-soluble fiber and this implies it can hold 18 g of water and expand by 325%. This phenomenon causes an increase in stool volume, thereby facilitating intestinal peristalsis, movement of stool in the colon and defecation. It is important to note that dietary fiber (DF) contains non-extractable polyphenols (NEPP) which is a main component of plant cells [54] that cannot be absorbed or released in the small intestine because it is generally bound to cellulose, hemicellulose and pectin. Therefore, its release and metabolism usually occur in the colon through a fermentation process conducted by microbiota [55, 56]. This signifies NEPP can be beneficial to health by regulating the environment in the colon and inhibiting the growth of carcinogenic microorganisms [57].

The material used in preparing gudeg is a whole young jackfruit consisting of pulp and seeds which have nutritional benefits. In general, research related to the nutritional content of jackfruit only focuses on the pulp and seeds of ripe jackfruit. Meanwhile, research on the nutritional content of young jackfruit is still limited. It has been previously reported that jackfruit seeds contain four phenolic acids, including ferulic, caffeic, tannic

and gallic acids. Young jackfruit seeds (raw fruit seeds) contain tannic acid, gallic acid, ferulic acid and caffeic acid, respectively, 6.59 ± 0.07 , 11.3 ± 1.6 , 2.38 ± 0.01 and 2.84 ± 0.02 $\mu\text{g/g}$ fresh sample. Meanwhile, ripe jackfruit seeds have different phenolic acid content compared to raw fruit seeds, including tannic acid, gallic acid and ferulic acid, respectively, 2.21 ± 0.01 , 11.30 ± 1.07 and 2.71 ± 0.01 $\mu\text{g/g}$ fresh sample, while caffeic acid was not detected due to being under detection limit [58]. Consumption of foods containing phenolic acids has antioxidant potential and provides benefits for human health that can prevent cell damage due to free radical oxidation reactions. Regular consumption of phenolic acid also increases the anti-inflammatory capacity of human beings [59]. It has been previously reported that the antioxidative effect of phenolic compounds is to inactivate free radicals from lipid peroxidation [60]. Phytochemicals considered to be natural antioxidants, such as carotenoid amino acids, phenolics and flavonoids, provide several health benefits. Some other compounds, such as phenolics and their metabolites, are also important for pathogenicity, infestation and photo-oxidation [60]. In another study, young jackfruit seeds contained calcium and magnesium, respectively, 23.7865 ± 0.6937 mg/100 g and 29.0621 ± 0.3830 mg/100 g, where the calcium content in ripe jackfruit seeds is lower, 17.7813 ± 1.2756 mg/100 g [61].

The demand for healthy, varied, nutritious and convenient food by consumers led to the ongoing improvements to existing procedures as well as new developments in food processing directed toward producing safe foods while keeping their nutritional and sensory attributes. It is important to note that the sensory properties of these traditional products are required to develop innovative products [3]. Putra et al. [32] studied the consumer ratings of each of the sensory attributes of wet and dry gudeg and showed positive rating concerning taste and appearance for both, but the dry type had higher rating. This proves that the taste of dry gudeg is preferred over the wet type even though they both had positive assessment and similar trend was also reported for the appearance attributes with the dry type considered by the consumers to be more attractive. *Manggar* gudeg has a taste that is almost the same as gudeg jackfruit, because it uses the same spices. However, the difference between *manggar* gudeg and jackfruit gudeg is in the texture. The gudeg jackfruit has a soft texture, while the *manggar* gudeg has a slightly crunchy texture [52]. *Manggar* gudeg cannot be found in every restaurant because the main ingredient, whole coconut flower, is difficult to find. This is because taking whole coconut flowers makes the coconut unproductive and will not bear fruit. Moreover,

Table 4 Nutritional content of jackfruit gudeg

Nutrition content	Jackfruit gudeg*	Canned gudeg	<i>Manggar</i> gudeg
Energy	1027.75 kcal	–	866.98 kcal
Water	267.09 g	73.28%	412.74 g
Protein	39.75 g	5.33%	73.27 g
Fat	47.25 g	5.12%	28.24 g
Carbohydrate	110.75 g	12.47%	79.93 g
Mineral	10.17 g	1.72%	5.82 g

*And rice (per portion: 475 g)

manggar gudeg has a more expensive price than jackfruit gudeg [62].

Nurhikmat and Hendrix [3] also studied the sensory quality of canned gudeg and found the effect of storage on the texture, taste and overall quality. This phenomenon is associated with the sterilization process at high temperatures which has the ability to change the physical and chemical properties of the food as indicated by the changes in the precipitation, coagulation of protein and texture. This is possible because the canned gudeg requires an appropriate sterilization process to destroy microorganisms while maintaining its sensory and nutritional qualities during the production process. Meanwhile, these sensory attributes are normally influenced by individual perceptual variability such as the physiological, anatomical and cultural differences of consumers as well as their genetics, gender, habits, age and disease considered to be closely related to the modulation of olfactory capacity [3, 63]. According to the Fibri and Frøst [44], information, as an external factor, also has a strong effect on the sensory properties of traditional foods as indicated by the information related to raw materials, production methods and products' provenance. This shows that product information is an important factor related to consumers' perception of gudeg due to the fact they normally consider the sensory aspects, tradition, convenience and ease of cooking in selecting traditional foods [64].

Conclusion

Gudeg is a typical Yogyakarta and Central Java food made from young jackfruit and cooked with coconut milk. It takes a long time to make this dish, and a brown color is usually produced by cooking together with teak leaves. Gudeg is eaten with rice and served with thick coconut milk (areh), chicken, eggs, tofu, krecek and chili. Furthermore, it has a long history, especially in the areas of Central Java and Yogyakarta, and is currently sold and consumed by the community. Therefore, it has become an iconic food in Indonesian tourism.

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Author contributions

BY is interested in the manuscript writing and the findings analysis. BY has been involved in the process of data collection and preparation of the analysis. The author read and approved the final manuscript.

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Declarations

Competing interests

The authors declare that they have no competing interest.

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