Agrointek Volume 18 No 3 September 2024: 581-592

p-ISSN: 1907-8056
e-ISSN: 2527-5410
AGROINTEK
Jurnal Teknologi Industri Pertanian
journal homepage: journal.trunojoyo.ac.id/agrointek

Comparative microbiological, chemical, and sensory traits of aron fermentation in Tengger and laboratory scales

Oki Krisbianto[1], Andre Yusuf Trisna Putra[2], Masdiana Chendrakasih Padaga[1], Hari Minantyo[3*]

[1]*Food Technology, Universitas Ciputra, Surabaya, Indonesia*
[2]*Food Technology, UPN "Veteran" Jawa Timur, Surabaya, Indonesia*
[3]*Tourism-Culinary Business, Universitas Ciputra, Surabaya, Indonesia*

Article history
Received:
3 September 2023
Revised:
21 October 2023
Accepted:
22 October 2023

Keyword
Aron;
corn;
lactic acid bacteria;
mount Bromo;
sensory;
traditional food

ABSTRACT

Aron, a traditional fermented food of the Tengger community, is made from white corn grown in Bromo and has received limited microbiological, chemical, and sensory research attention to date. The research objective was to compare microbiological, chemical, and sensory traits between in situ-produced aron on the slopes of Mount Bromo and ex situ-produced aron in a laboratory in Surabaya. A specific strain of lactic acid bacteria was isolated using de Man, Rogosa, and Sharpe (MRS) Agar from samples of sun-dried white corn. This strain was identified as Gram-positive cocci. In contrast, a different strain of Gram-positive bacilli was found in corn-soaking water, both in situ and in laboratory-fermented aron, on days 0, 7, and 16. Chemical analysis revealed no significant differences in protein, fat, and ash content between the two variables. However, laboratory-fermented aron exhibited higher moisture content. This discrepancy significantly influenced the hedonic texture data for aron, with in situ aron being perceived as drier and more mouth-soluble, while laboratory-fermented aron had a softer texture. Furthermore, the high microbial growth during the fermentation process resulted in aron with a distinct and relatively strong aroma that was less favored by the panelists. The difference in the fermentation location of white corn did not affect the types of lactic acid bacteria that thrived, the nutritional compound content, and the appearance of aron. The variation in the aroma of aron is believed to be primarily influenced by the number of bacteria rather than their specific strains.

* Corresponding author
Email : hari.minantyo@ciputra.ac.id
DOI 10.21107/agrointek.v18i3.22236

INTRODUCTION

Fermentation processes represent one of the traditional food preservation methods used by various cultures worldwide (Anagnostopoulos and Tsaltas 2019, Tamang et al. 2020). Fermented food products have long been recognized in Indonesia, both in agriculturally productive and less productive regions (Angelia et al. 2019, Damayanti et al. 2021). Some carbohydrate-based food fermentation products well-known among the communities in Java Island include *gaplek*, *gatot*, and *growol*, which are made from cassava.

Numerous studies have successfully identified microorganisms that thrive during the production process of *gaplek* and *gatot*, particularly fungi such as *Aspergillus flavus*, *A. niger*, *Rhizopus oryzae*, *R. oligosporus*, *Botryodiplodia theobromae*, *Acremonium charticola*, *Lasiodiplodia theobromae*, *Trichoderma* sp., and *Fusarium oxysporum*; yeast such as *Candida tropicalis*; as well as lactic acid bacteria (LAB) such as *Lactobacillus plantarum*, *Lb. pentosus*, *Lb. fermentum*, *Lb. manihotivorans*, *Pediococcus pentosaceus*, and *Streptococcus thermophilus* (Angelia et al. 2019, Damayanti et al. 2021, Hallis et al. 2021). LAB can ferment carbohydrates and produce organic acids, mainly lactic acid, which can inhibit the growth of pathogenic, toxigenic, and putrefaction microorganisms, lower natural toxins like cyanide in cassava, and hold potential as probiotics (Anagnostopoulos and Tsaltas 2019, Catherine and Okechi 2019, Nwachukwu et al. 2019, Hallis et al. 2021, Wang et al. 2021). Furthermore, LAB are generally considered safe and widely employed in the food industry (Emkani et al. 2022).

One of the lesser-known fermented food products, even among the inhabitants of Java Island, is *aron*. Aron is a product made of fermented white corn (*Zea mays*) that serves as the staple food of the Tengger tribe, residing around the volcanic cone of Bromo and the northern slopes of Mount Semeru (Krisbianto et al. 2023). Concisely, aron can be described as a variant of sourdough corn cake. The white corn traditionally cultivated by the Tengger community is of Indian origin and has been grown since the Dutch colonial era to meet the dietary needs of the local laborers in Pasuruan County, West Java (Hefner 1999, Official Tourist Bureau Weltevreden 2018). This variety has a growth period ranging from 9 to 12 months due to the specific corn variety and the climate zone of the Tengger mountain slopes, which are classified as moderate climates according to Junghuhn (Worsfold 1893, Batoro 2021). As a Tenggerese heritage staple food, aron has begun to be abandoned due to its replacement by rice, primarily because of its lengthy and intricate preparation process, necessitating collective efforts for its preservation (Krisbianto et al. 2023).

The method of making aron from white corn is unique but quite similar to the production processes of gaplek and gatot. Harvested white corn, still encased in its husk, is left to sun-dry in the cold and frequently foggy weather of the Tengger region. Typically, it is stored by hanging around the kitchen hearth. The resulting corn kernels become extremely hard and may occasionally develop mold, commonly attributed to xerophilic groups such as *Aspergillus* and *Fusarium* (Yazid et al. 2021, Qi et al. 2023, Katati et al. 2023). Subsequently, the corn kernels are pounded until the husk is removed, washed thoroughly with water from the Bromo water supply they use, and soaked for around one week, with the soaking water being changed every few days. This soaking process can extend for more than a month.

The soaked corn kernels develop a sour smell and must be washed several times until clean. Subsequently, the softened corn kernels are ground into flour and steamed to produce aron. In the more traditional method, women pounded corn kernels with a small amount of water using wooden mortars, each measuring approximately 1 meter. However, this method has largely been abandoned due to concerns about its association with a higher incidence of miscarriages. The corn flour is then steamed to make aron and can be consumed either in the form of cake (referred to as *aron*) or finely crushed (referred to as *nasi gerit*).

So far, aron has only been mentioned in social and agricultural research (Batoro 2021, Putri et al. 2022, Tribrata et al. 2023, Sucipto et al. 2023). No research has reported the microorganisms that grow during the aron-making process, their chemical composition, and sensory evaluations of aron, particularly regarding the growth of lactic acid bacteria, which offer various health and food safety benefits. Furthermore, there have yet to be any reports on whether aron can be produced outside the Tengger region, with different water sources, air conditions, and temperatures from its origin. Several studies have indicated that variations in altitude affect the types of microorganisms, including lactic acid bacteria, that flourish, while geographical location exerts a significant influence (Tolera and Ashenafi 2011, Chaves-López et al. 2020, Sun et al. 2023). This is to ascertain the potential for developing Tengger's unique food industry based on aron (Krisbianto et al. 2023). Nevertheless, several studies indicate that microorganisms involved in corn fermentation typically include lactic acid bacteria and yeast, with mold and pathogenic microorganisms (Chaves-López et al. 2020).

This research is a fundamental study, laying the foundation for further aron research based on food science and technology. This study aimed to determine whether there were differences in the growth of lactic acid bacteria, chemical composition, and sensory traits between aron produced in situ and ex-situ in a laboratory setting. The heightened scholarly attention directed toward aron is anticipated to elevate Tenggerese cultural awareness and foster a sense of pride in their traditional culinary heritage. This, in turn, may facilitate its introduction to local and international tourists visiting the region.

METHODS

Research Design and Raw Materials

This study utilized a Randomized Block Design, with the research parameter being the production location of aron, and each location had three groups or replications. The first location is in Sanggar Hamlet, under the administration of Wonokitri Village, Tosari Subdistrict, Pasuruan Regency, East Java Province, Indonesia. The second location is in the Microbiology Laboratory, Food Technology Program, Universitas Ciputra Surabaya, East Java Province, Indonesia.

The group assignment was based on the origin of sun-dried white corn as the raw material sourced from three households in Sanggar Hamlet. The white corn was presented as sun-dried kernels that had undergone a polishing process to eliminate the husk. Each household's raw material was divided into two parts, with one part allocated for aron production at the owner's residence, and the remaining were employed in aron production at the Microbiology Laboratory in Surabaya. The corn variety they possessed was of Indian origin and had been under cultivation in the Tengger region since the colonial era.

The water used for aron production in Bromo is derived from a water source managed by the local government of Wonokitri Village, hereafter referred to as the Bromo water supply. The water used in the laboratory was commercial bottled gallon water (Indomaret, Indonesia).

Aron Production Process

The aron production took place from July to August 2023. The in fermentation of dried corn was conducted by three housewives, each in a different house. The aron-making conditions were maintained following each household's practices, accommodating the required quantities for each family. The process of aron production is illustrated in Figure 1.

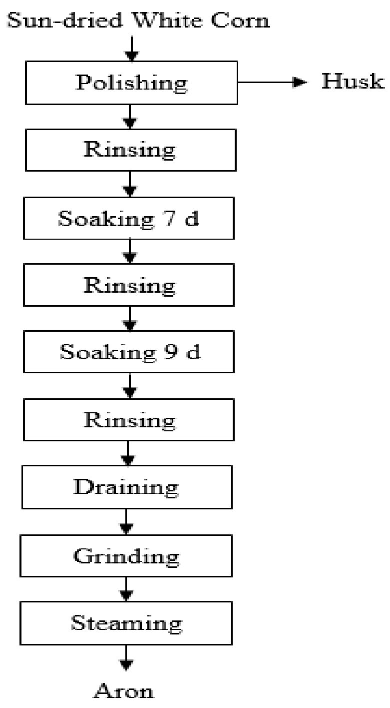

Figure 1 The process of aron production

The sun-dried white corn was washed six to seven times using the Bromo water supply until the washing water became clear.

The white corn was subsequently immersed in plastic buckets with lids and stored in three separate locations: the backyard terrace of the first house, the interior of the second house, and the front terrace of the third house. The soaking water was changed on the seventh and sixteenth days. After the sixteenth day, the fermented white corn was rinsed four to six times until the soaking water became clear. It was then drained using a sieve, placed in plastic containers wrapped in plastic wrap for transportation to Surabaya, and stored in a refrigerator (Polytron, PR 17 Seri, Indonesia) at 4°C before undergoing analysis. During the fermentation process, the ambient air temperature in the Wonokitri Village, including Sanggar Hamlet, ranged from approximately 10-20°C, based on observations made by a resident during daytime and nighttime. Notably, the first and second houses were adjacent and separated by a narrow entrance alley, resulting in relatively similar air conditions. This contrasted with the third house, which was in a different block. The fermentation areas of the first and second houses were adequately shaded and covered by roofs, whereas the front terrace of the third house, positioned right next to the village's main road, was relatively less shaded and more exposed to sunlight.

The research team conducted laboratory fermentation following the process demonstrated by the three homemakers but in a more aseptic environment and procedure. A total of 250 grams of sun-dried white corn from each household was washed six to seven times, soaked, stored in sealed glass containers covered with plastic wrap, and placed in a closed cupboard. The soaking water was changed on the seventh day, and the corn was rinsed thoroughly on the sixteenth day. The fermented white corn was drained and then stored in plastic containers in a refrigerator (Polytron, PR 17 Series, Indonesia) at 4°C before undergoing analysis. The laboratory fermentation process occurred at an ambient temperature of around 23-25°C, as measured by a thermometer during the daytime and late evening.

The fermented white corn was ground using a compact food processor (Bosch, CNC12, Slovenia) and coarsely sieved using a sieve of approximately 20 mesh size. Afterward, it was steamed for 30 minutes to become aron. Aron samples were stored in LDPE bags and placed in a refrigerator (LG, GC-B2475LUW, China) set at 4°C before undergoing chemical and sensory analysis.

Microbiological Analysis

The microbiological analysis for enumerating lactic acid bacteria was conducted following the procedures outlined in the laboratory manual (Cappuccino and Welsh 2019). Colony counting was performed according to SNI 2897:2008 (Badan Standardisasi Nasional 2008). The materials used for preparing selective media for lactic acid bacteria included de Man, Rogosa, and Sharpe (MRS) Agar (Merck KGaA, Germany) and RO water (Kusatsu, RO-200G-P01, Japan). Media sterilization was done using an autoclave (Hirayama, HVE-50, Japan).

Sample collection for microbiological testing was conducted on dried corn (CC), soaking water samples from in situ aron production on days 0, 7, and 16 (CIS-0, CIS-7, and CIS-16, respectively), and in the laboratory on days 0, 7, and 16 (CL-0, CL-7, and CL-16 respectively). The soaking water in the corn was replaced on the 7th day after sampling.

Dried corn samples were collected from 5 different points within the container, mixed until homogenous, and then crushed using a mortar sterilized with 70% ethanol. The soaking water samples were collected from 5 points around the surface of the soaked corn kernels, mixed until homogenous, and stored in a cooling box before being tested within 6 hours after sampling.

A total of 25 grams of either dried corn samples or soaking water samples were dissolved in 250 ml of Buffered Peptone Water (Merck KGaA, Germany). LAB was then grown using the pour plate method with dilutions of $10^{-3} – 10^{-5}$ for dried corn samples, dilutions of $10^{-4} – 10^{-6}$ for 0 and 7-day soaking water samples, and dilutions of $10^{-6} – 10^{-8}$ for 16-day soaking water samples. Incubation was carried out at 30°C (Memmert, IN55, Germany) for 48 hours, as incubation at 37°C yielded unsatisfactory colony growth. Bacterial colonies were counted using a colony counter (Funke Gerber, Colony Star, Germany). Bacterial cells were stained with a Gram stain kit (Himedia, India), observed using a trinocular microscope (Olympus, CX31, China), and subjected to a catalase test using 3% hydrogen peroxide (OneMed, Indonesia).

Chemical Analysis

Proximate analysis was conducted on cooked aron samples obtained from in situ corn fermentation (AIS) and laboratory fermentation (AL) following the methods outlined in AOAC (Association of Officiating Analytical Chemists 2005). Ash content was analyzed using thermogravimetric analysis (method 923.03) with a muffle furnace (Thermo Scientific, FD1530M-33, USA). Moisture content was determined using thermogravimetric analysis (method 925.09) with an oven (Memmert, UF55, Germany). Fat content was analyzed using the Soxhlet method (method 920.39) with n-hexane as the solvent (Bratachem, Indonesia) and a rotary evaporator instrument (Heidolph, Hei-VAP Precision, Germany) with a cooling machine (Lauda, Alpha RA 8, Germany). Protein content was determined using the Kjeldahl method with a speed digester (Buchi, K-425, Switzerland) and a distillation unit (Buchi, K-365, Switzerland). The reagents used for protein analysis included Kjeldahl tablets 4.0 g containing 3.988 g K_2SO_4 dan 0.002 g $CuSO_4.5H_2O$ (Buchi, Switzerland), H_2SO_4 (UPT BPPTK LIPI, Indonesia), NaOH (Merck KGaA, Germany), boric acid (Smart-Lab, Indonesia), HCl (Sigma-Aldrich, USA), and Bromocresol Green indicator (Mediss, Indonesia). Carbohydrate content was calculated by difference.

Sensory Analysis

The hedonic sensory evaluation procedure was carried out by SNI 01-2346-2006, following the protocol outlined by Karsten et al. (2023). Using convenience sampling, hedonic testing involving 31 untrained panelists was conducted at the Sensory Laboratory, Food Technology Program, Universitas Ciputra Surabaya. The testing criteria included appearance (kernel shape and color), aroma, texture (softness and chewiness), and taste. The evaluation was performed using a 7-point Likert scale ranging from "very disliked" to "very liked." The sensory results were ranked using the Simple Additive Weighting (SAW) method, with a weight of 25% for each sensory criterion (Panjaitan 2019).

Data analysis

The Kjeldahl Optimizer Ver. 2.0 application (BÜCHI Labortechnik AG, Germany) was used to calculate the chemical reagent requirements for protein analysis using the Kjeldahl method. Data processing and statistical tests, including t-tests and analysis of variance (ANOVA) at a significance level of 5%, along with Duncan's multiple range test (DMRT) as a post hoc test, were performed using Microsoft Excel Office 365 A1 Plus (Microsoft Corporation, USA) and IBM SPSS Version 25 (IBM, USA).

RESULTS AND DISCUSSION

The fermentation process of food in Asia and Africa generally occurs spontaneously without the use of starter cultures (Tamang et al. 2020). This is also the case with aron, a traditional food product of the Tengger ethnic group. Therefore, it was proposed that microorganisms that thrived during aron fermentation were significantly influenced by the indigenous microbes found on sun-dried white corn and the environmental factors, including the individuals engaged in the preparation process.

Microbiological Traits

The LAB colonies that grew on MRS Agar media in each of the samples CC, CIS-0, CIS-7, CIS-16, CL-0, CL-7, and CL-16 were of a single type with macroscopic and microscopic characteristics detailed in Table 1.

Macroscopically, the appearance of colonies that developed in each sample showed no differences. According to Sulmiyati et al. (2018), the macroscopic appearance of LAB colonies is characterized by a circular shape, white color, entire margin, and convex elevation with a diameter size of approximately 0.5 - 1 mm. The same characteristics were observed in the colonies that grew from CC, CIS, and CL samples. Furthermore, these colonies were presumed to have facultative anaerobic features because they could grow both on the surface and within the media. However, the microscopic characteristics of the bacteria that grew in samples CC, CIS-0, and CL-0 differed from those in CIS-7, CIS-16, CL-7, and CL-16. Meanwhile, the microscopic appearance also displays characteristics indicative of lactic acid bacteria, including being Gram-positive, non-spore-forming, aerotolerant, and catalase-negative, as shown in Figure 2 (Anagnostopoulos and Tsaltas 2019, Catherine and Okechi 2019, Emkani et al. 2022, Meena et al. 2022).

Table 1 Macroscopic and microscopic characteristics of LAB on MRS Agar

Samples	Macroscopic	Microscopic	Gram	Catalase
CC, CIS-0, CL-0	White, glossy, circular shape, entire margin, convex elevation, c. 0.5 – 1 mm in diameter.	Cocci	Positive	Negative
CIS-7, Cl-7, CIS-16, CL-16	White, glossy, circular shape, entire margin, convex elevation, c. 0.5 – 1 mm in diameter.	Rods	Positive	Negative

Note: CC= dried white corn samples; CIS= in situ soaking water samples; CL= laboratory soaking water samples.

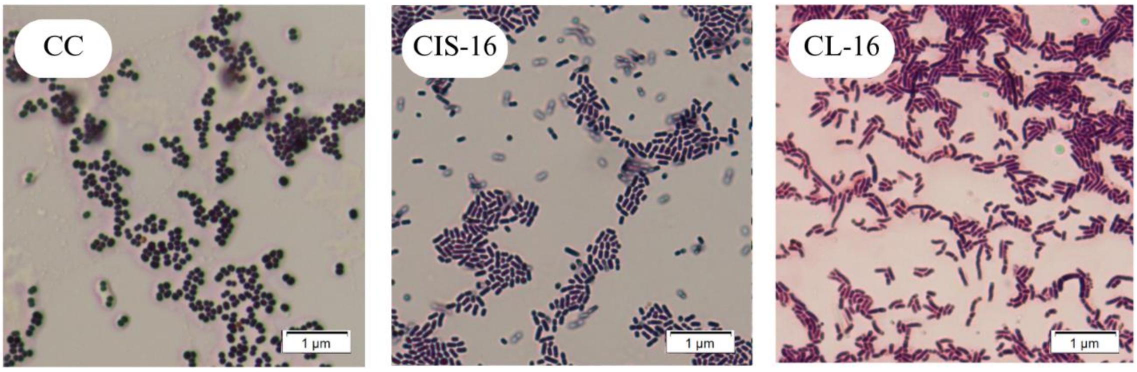

Figure 2 Results of Gram staining of bacterial cells grown on dried corn (CC), in situ soaking water (CIS), and laboratory soaking water (CL). Magnification at 1000x.

Initially, it was hypothesized that the bacterial species that proliferated were affected by differing fermentation environmental factors, with particular emphasis on geographical isolation, which makes the microorganisms growing on Tengger white corn unique. Geographical isolation affects the differences in the water used, the fermentation container and storage location, the air condition, the temperature, and the people engaged in the preparation process (Chaves-López et al. 2020). Surprisingly, the data revealed the same types of lactic acid bacteria that thrived in situ in Sanggar Hamlet and the Microbiology Laboratory in Surabaya. The colony of lactic acid bacteria likely originated in the raw material of dried white corn rather than environmental sources. Furthermore, the fermentation process of white corn in the laboratory was carried out in a relatively aseptic manner. Differences in air temperature, water characteristics, and other factors had minimal if any, impact on the type of lactic acid bacteria colonies that grew and dominated during the fermentation process. Nevertheless, the distinction between the types of bacteria that grew and dominated in the CC, CIS-0, and CL-0 samples as compared to the other samples warrants attention.

The dried corn sample (CC) was inhabited by Gram-positive coccus-shaped bacteria, presumed to be *Lactococcus* or *Streptococcus* (Zirnstein and Hutkins 2000, Van der Meulen et al. 2007). Before 2007, *Streptococcus thermophilus* strains had never been identified in plant sources. Subsequently, numerous research studies have isolated different strains from plant materials (Umamaheswari et al. 2014, Saito et al. 2020). Unfortunately, research on lactic acid bacteria is generally confined to their applications in fermentation and probiotics, resulting in limited information regarding lactic acid bacteria in plants. Nevertheless, cocci such as *Lactococcus*, *Streptococcus*, *Leuconostoc*, and *Lactobacillus* are frequently detected in plant tissues (Yu et al. 2020).

Meanwhile, the final in situ fermentation (CIS) and laboratory-fermented (CL) samples were populated by Gram-positive rod-shaped bacteria suspected to be *Lactobacillus* (Meena et al. 2022). This finding is interesting because *Lactobacillus* is the most found genus in lactic acid-fermented foods, although *Lactococcus* and *Streptococcus* are also frequently encountered in cereal fermentation products (Anagnostopoulos and Tsaltas 2019, Catherine and Okechi 2019). Spontaneous fermentation will lead to microecological stability, as evidenced by the final product demonstrating similar characteristics (Van der Meulen et al. 2007). Cocci lactic acid bacteria, such as *Lactococcus* and *Streptococcus*, thrive in a pH range that is relatively less acidic compared to *Lactobacillus*, which prefers a more acidic pH range. Consequently, cocci colonies are typically found at the beginning of fermentation and replaced by *Lactobacillus* colonies (Van der Meulen et al. 2007).

Interestingly, similar results were observed in the fermentation of *pap* or *ogi*, a type of African fermented food made from maize and other grains. *Streptococcus* was only detected during the first and second days of fermentation, while *Lactobacillus* was newly identified from the second day to the fifth day or the final day of fermentation (Anumudu et al. 2018). *Lactobacillus*, particularly *L. plantarum*, is frequently identified as the predominant lactic acid bacterium in the final products of cereal fermentation, possibly due to its highly adaptive carbohydrate metabolism (Van der Meulen et al. 2007).

Meanwhile, the number of LAB colonies that grew on MRS Agar media is presented in Table 2. There were no significant differences at the 5% level based on groups based on the origin of the dried white corn raw materials from three households in Sanggar Hamlet. The bacterial count in the water on day 0 (CIS-0 and CL-0) did not significantly differ from that of the dried white corn despite washing and rinsing, performed six to seven times. During the initial washes, the soaking water turned into a highly cloudy milky white, while the water had become clear by the final wash.

Lactobacillus, as the LAB group, possesses amylolytic activity, making it thrive on cereals which are primarily a source of carbohydrates, especially starch (Wang et al. 2021, Kayitesi et al. 2023). The data showed an increase in colony count on day seven compared to day 0, especially in the CIS samples. Still, there was no significant difference between the CIS and CL samples' colony counts on days seven and 16. The data indicates that the growth of microorganisms had not yet reached the death phase during the corn soaking process until day 16, with the note that the soaking water was replaced on day 7.

Chemical Traits

The milling processes of fermented white corn and the cooking of aron were carried out under the same conditions and equipment. The results of the proximate analysis of aron on a wet basis (%wb) and dry basis (%db) are presented in Table 3. Based on the %wb data, moisture content and carbohydrates were the nutrient components that differed significantly between aron produced in situ (AIS) and in the laboratory (AL). However, based on the %db data, no significant differences were observed in any of the components. This indicates that the differences during the production of in situ and laboratory aron did not significantly impact the macromolecular nutrient components of aron.

Nonetheless, it is conjectured that disparities in the macromolecular structures of corn before and after fermentation may exist, such as amylose and amylopectin, vitamins, peptides, and amino acids, which were not analyzed in this study (Chaves-López et al. 2020). These components potentially affect the nutritional properties and texture of aron. Further research and analysis would be needed to explore these aspects further.

Table 2 The number of LAB colonies on MRS Agar

Samples	Units	Colony count
CC	cfu/g	1.0×10^{5} [a]
CIS-0	cfu/ml	1.5×10^{5} [a]
CIS-7	cfu/ml	9.7×10^{7} [b]
CIS-16	cfu/ml	9.0×10^{7} [b]
CL-0	cfu/ml	3.0×10^{5} [a]
CL-7	cfu/ml	4.7×10^{7} [ab]
CL-16	cfu/ml	3.6×10^{7} [ab]

Note: Different notations indicate significant differences at a significance level of 5%. CC = dried corn samples; CIS = in situ soaking water samples on days 0, 7, and 16; CL = laboratory soaking water samples on days 0, 7, and 16.

Table 3 Proximate analysis of aron

Content	%wb		%db	
	AIS	AL	AIS	AL
Moisture	37.85±2.84*	43.73±0.55*	-	-
Ash	0.19±0.09	0.15±0.05	0.30±0.14	0.26±0.08
Protein	5.09±0.93	5.00±0.76	8.15±1.23	8.87±1.31
Fat	1.15±0.39	0.84±0.14	1.83±0.59	1.50±0.24
Carbohydrate	55.72±1.79*	50.29±0.54*	89.71±1.47	89.37±1.27

Note: An asterisk (*) on the same row and within the same column group (%wb or %db) indicates a significant difference at the 5% significance level. AIS represents aron samples fermented in situ; AL represents aron samples fermented in the laboratory

Table 4 Sensory analysis of aron

	AIS1	AIS2	AIS3	AL1	AL2	AL3
Appearance	4.58±0.32^{a}	4.68±0.30^{a}	4.90±0.27^{a}	4.55±0.27^{a}	5.10±0.28^{a}	5.13±0.31^{a}
Aroma	4.42±0.24^{bc}	4.29±0.29^{bc}	2.87±0.31^{a}	4.52±0.22^{bc}	4.71±0.24^{c}	3.74±0.30^{b}
Texture	4.42±0.22^{b}	4.42±0.32^{b}	4.00±0.25^{ab}	4.29±0.26^{ab}	4.03±0.29^{ab}	3.48±0.29^{a}
Taste	4.23±0.24^{a}	4.10±0.28^{a}	4.00±0.27^{a}	4.03±0.23^{a}	3.71±0.32^{a}	4.06±0.35^{a}
Rank (SAW)	1	2	6	4	3	5

Note: Different notations within the same row indicate a significant difference at the 5% significance level. AIS1, AIS2, and AIS3 represent aron samples fermented in situ at the first, second, and third Tengger households. AL1, AL2, and AL3 represent aron samples fermented in the laboratory using dried corn from the first, second, and third Tengger households. The SAW method ranking selection indicates the most preferred sample (1) to the least preferred (6).

Food digestibility is significantly improved through LAB fermentation, wherein carbohydrate molecules, encompassing starch and fiber, are degraded into smaller, more easily digestible compounds. The elevation of free amino acids, particularly those containing sulfur and tryptophan, is achieved through processes such as proteolysis or metabolic synthesis and plausibly involves the synthesis of vitamins, primarily attributed to the capabilities of *Lactobacillus* to the production of folic acid (Anagnostopoulos and Tsaltas 2019, Wang et al. 2021, Ma et al. 2022). Fermentation of corn flour with *Lactobacillus plantarum* culture increases protein content, implying microbial protein synthesis, while simultaneously improving in vitro digestibility and reducing phytate, tannin, and trypsin inhibitor activities (Terefe et al. 2021). Furthermore, mineral digestibility generally improves due to the degradation of phytate compounds, which naturally act as antinutrients inhibiting the absorption of minerals from plant-based foods (Anagnostopoulos and Tsaltas 2019).

The difference in moisture content of AIS and AL was presumed to be due to variations in the draining process conducted by the Tengger residents compared to that in the laboratory. The draining process in Tengger was carried out more thoroughly, resulting in relatively drier fermented white corn. The corn fermented in the laboratory was wetter, with some water pooling visible between the corn kernels. Differences were also noticed during the milling process, where the in situ corn was more accessible to grind into flour despite its relatively wet condition. In contrast, the laboratory corn was stickier due to its wetness, making it more challenging to sieve. These factors affected the moisture content of aron after cooking and should be a concern for future research.

The difference in moisture content ultimately influenced the carbohydrate content %wb, which was calculated by difference. Meanwhile, the carbohydrate content %db did not significantly differ between the two variables.

Sensory Traits

Sensory analysis of the aron was conducted by 31 panelists. Each replication of the variable was evaluated separately, resulting in 6 sensory data points, as presented in Table 4. The assessed liking indicators included appearance (grain shape, size, and color), aroma, texture (softness and chewiness), and taste.

The sensory results ranking indicated that the location of white corn fermentation had a minor influence compared to other factors that affected aroma and texture. Additionally, there were no significant variations in preference for appearance and taste among the samples.

The taste components in fermented cereal products originate from non-volatile compounds such as flavonoids, amino acids, peptides, and organic acids (Kayitesi et al. 2023). From the data, it was obtained that there was no significant difference in preference regarding appearance and taste. In addition, panelists also commented that the taste of the aron samples was relatively similar, with a somewhat bland taste. Tribrata et al. (2023) also provided a similar description, who mentioned that aron is tasteless. This can be influenced by the relatively low protein and fat content of aron, which may not contribute much to taste variation. Furthermore, the color of each sample appeared to show almost no differences, and the aron grains had relatively similar sizes since they were ground and sieved using the same equipment.

Aron exhibited a soft and lumpy texture (Tribrata et al. 2023). Fermentation breaks down the complex macromolecular structure of dried corn, especially starch and fiber, into simpler forms, resulting in softer dried corn that can be easily crushed by pressing it with one's fingers (Anagnostopoulos and Tsaltas 2019, Ma et al. 2022).

This study found that AIS samples had a harder texture but quickly dissolved when placed in the mouth, unlike the AL samples, which were softer, akin to white bread. The differences in texture perception are believed to be due to variations in AIS and ALS's moisture content. AIS has a lower moisture content, making it feel harder but easier to break apart, whereas AL is softer. A similar case is observed with the texture of the moist cake, where lower moisture content results in higher crumb firmness (Mior Zakuan Azmi et al. 2019). Another factor that may be at play is the difference in the levels of amylose, amylopectin, and dietary fiber resulting from the fermentation of dried corn in situ and in the laboratory. These factors need further investigation as this study did not conduct related analyses.

The sensory evaluation that stood out the most was the assessment of aroma. Samples AIS3 and AL3 had a distinctive smell that, according to one panelist, resembled spoiled tofu, but the aroma of AL3 was not as strong as that of AIS3. This aroma is believed to have originated from lactic acid bacteria fermentation during the corn-soaking process. Based on bacterial colonies, the number of colonies in the third replicate sample of CIS-16 was the highest compared to the other replicates. Likewise, during field observations, the sample under discussion appeared the cloudiest and emitted the strongest fermentation aroma, as LAB can produce aroma and viscous exopolysaccharides (Wang et al. 2021). Although the number of colonies in the third replicate of the CL-16 sample did not significantly differ from the other two replicates, it should be noted that the third replicates of both CIS and CL samples used the same batch of dried white corn as the raw material.

Further research is needed to determine the most influential factors contributing to the unique aroma of aron, whether it arises from the number of bacteria that grow during the soaking process or other factors. However, it can be confirmed that fermentation activities enhance the flavor of food products. (Anagnostopoulos and Tsaltas 2019, Wang et al. 2021). Especially because *Lactobacillus* have homofermentative characteristics (Wang et al. 2021, Meena et al. 2022). Furthermore, the frequency of changing the soaking water also plays a role in shaping the aroma of aron, with less frequent water changes resulting in a more intense aroma, as also mentioned by Tribrata et al. (2023). The low protein and fat content are believed to contribute little to the aroma variation in aron in the form of aromatic amino acids, esters, or their derivative products, except for free fatty acids that contribute to the sour aroma (Kayitesi et al. 2023).

One of the advantages of the fermentation process is enhancing the flavor and aroma of generally bland cereals by forming volatile components such as organic acids and derivatives of amino acids resulting from proteolysis (Anagnostopoulos and Tsaltas 2019). However, the distinct aroma of aron was relatively disliked by all Indonesian panelists. Similar opinions were expressed by several individuals who had previously consumed aron. Two factors affect food preferences, i.e., endogenous factors, such as sociocultural factors, and exogenous factors, such as motivations and needs, perceptions, the learning process, and so on (Negrea et al. 2021). Nation differences contribute to the sociocultural variations among panelists and consumers (Sánchez et al. 2023). This was demonstrated by a German student who tasted the samples and offered feedback, noting that, in contrast, sample AIS3 presented the most enjoyable flavor compared to other samples that were perceived as bland. It shows that panelists' backgrounds influence their food preferences, providing valuable insights for the development of aron as the heritage food of the Tengger ethnic group, who host tourists, both domestic and international, visiting Bromo.

CONCLUSION

The fermentation of sun-dried native white corn grown in Bromo agriculture under different and warmer environmental conditions on the laboratory scale resulted in aron with characteristics that were relatively similar to those produced in situ around the Bromo region. Differences in the fermentation environment do not impact the types of LAB that thrive in aron fermentation nor its protein, fat, and ash content of aron. The aroma of aron is influenced by the quantity of microorganisms present, but it does not impact its color, appearance, and taste.

ACKNOWLEDGEMENT

The Directorate General of Higher Education, The Ministry of Education, Culture, Research, and Technology, Republic of Indonesia, funded this research (Contract Number 044/SP2H/PT/LL7/2023). We gratefully thank for the support of KUBE Delvia and the Tengger community in the Wonokitri Village, to the Food Technology Program of Universitas Ciputra Surabaya for kindly providing laboratory equipment, as well as all research assistants from the Food Technology Programs of UPN "Veteran" Jawa Timur and Universitas Ciputra Surabaya.

REFERENCES

Anagnostopoulos, D. A., and D. Tsaltas. 2019. Fermented Foods and Beverages. Pages 257–291 Innovations in Traditional Foods. Elsevier.

Angelia, C., A. Sanjaya, A. Aida, E. Tanudjaja, H. Victor, A. D. Cahyani, T. J. Tan, and R. Pinontoan. 2019. Characterization of Alpha-Amylase from Aspergillus niger Aggregate F Isolated from a Fermented Cassava Gatot Grown in Potato Peel Waste Medium. Microbiology and Biotechnology Letters 47:364–371.

Anumudu, C. K., F. I. Omeje, and G. N. Obinwa. 2018. Microbial succession pattern in Ogi fermentation. International Journal of Advanced Research in Biological Sciences 5:247–251.

Association of Officiating Analytical Chemists. 2005. Official methods of analysis. 18th edition. Association of Official Analytical Chemist, Inc., Washington DC.

Badan Standardisasi Nasional. 2008. SNI 2897:2008: Metode pengujian cemaran mikroba dalam daging, telur dan susu, serta hasil olahannya. Jakarta.

Batoro, J. 2021. Ethnobotany of Local Corn (Zea Mays L.) in Ngawu Sub-Village, Tosari District, Pasuruan Regency, East Java, Indonesia. Journal of Southwest Jiaotong University 56:610–615.

Cappuccino, J. G., and C. Welsh. 2019. Microbiology: a laboratory manual. 12th edition. Pearson, New York.

Catherine, A.-O. B., and K. I. Okechi. 2019. Evaluation of OGI (CORN CARAMEL) from Maize and Sorghum for Isolation and Characterisation of Lactic Acid Bacteria (LAB). Biochemistry and Molecular Biology 4:28–34.

Chaves-López, C., C. Rossi, F. Maggio, A. Paparella, and A. Serio. 2020. Changes Occurring in Spontaneous Maize Fermentation: An Overview. Fermentation 6:36.

Damayanti, E., M. Ichsyani, L. Istiqomah, A. S. Anggraeni, and M. Kurniadi. 2021. Fermentation of amylolytic yeast and lactic acid bacteria to improve the quality of modified cassava. IOP Conference Series: Materials Science and Engineering 1011:012004.

Emkani, M., B. Oliete, and R. Saurel. 2022. Effect of Lactic Acid Fermentation on Legume Protein Properties, a Review. Fermentation 8:244.

Hallis, S. P., A. T. Hartanti, and A. W. Gunawan. 2021. Molecular Diversity of Mold Associated with Gatotan. Microbiology Indonesia 15:1–7.

Hefner, R. W. 1999. Geger Tengger (The political economy of mountain Java and interpretive history). LKIS, Yogyakarta.

Karsten, H. E., E. O. Khaled, O. Krisbianto, M. I. Madyaratri, and F. Fatimah. 2023. Research and Development on Galengdowo Village's Tahu Walik Cracker Using Different Seasonings. Food Science and Technology Journal 6:33–41.

Katati, B., P. Schoenmakers, H. Njapau, P. W. Kachapulula, B. J. Zwaan, A. D. van Diepeningen, and S. E. Schoustra. 2023. Preharvest Maize Fungal Microbiome and Mycotoxin Contamination: Case of Zambia's Different Rainfall Patterns. Applied and Environmental Microbiology 89.

Kayitesi, E., O. Onojakpor, and S. M. Moyo. 2023. Highlighting the Impact of Lactic-Acid-Bacteria-Derived Flavours or Aromas on Sensory Perception of African Fermented Cereals. Fermentation 9:111.

Krisbianto, O., H. Minantyo, and J. Sahertian. 2023. Potensi Industri Pangan dalam Pengembangan Pariwisata Bromo: Persepsi Penduduk Desa Wonokitri. Jurnal Pariwisata Indonesia 5:134–145.

Ma, Z.-Y., E. Ungerfeld, Z. Ouyang, X.-L. Zhou, X.-F. Han, Y.-Q. Zeng, and Z.-L. Tan. 2022. Effect of Lactobacillus plantarum Inoculation on Chemical Composition, Fermentation, and Bacterial Community Composition of Ensiled Sweet Corn Whole Plant or Stover. Fermentation 8:24.

Meena, K. K., N. K. Taneja, D. Jain, A. Ojha, C. Saravanan, and D. Mudgil. 2022. Bioactive Components and Health Benefits of Maize-based Fermented Foods: A Review. Biointerface Research in Applied Chemistry 13:338.

Van der Meulen, R., I. Scheirlinck, A. Van Schoor, G. Huys, M. Vancanneyt, P. Vandamme, and L. De Vuyst. 2007. Population Dynamics and Metabolite Target Analysis of Lactic Acid Bacteria during Laboratory Fermentations of Wheat and Spelt Sourdoughs. Applied and Environmental Microbiology 73:4741–4750.

Mior Zakuan Azmi, M., F. S. Taip, S. M. Mustapa Kamal, and N. L. Chin. 2019. Effects of temperature and time on the physical characteristics of moist cakes baked in air fryer. Journal of Food Science and Technology 56:4616–4624.

Negrea, M., I. Cocan, E. Alexa, and D. Obistioiu. 2021. Consumers food preferences – influencing factors and methods of evaluation. Journal of Agroalimentary Processes and Technologies 27:424–431.

Nwachukwu, U., U. George-Okafor, U. Ozoani, and N. Ojiagu. 2019. Assessment of probiotic potentials of Lactobacillus plantarum CS and Micrococcus luteus CS from fermented milled corn-soybean waste-meal. Scientific African 6:e00183.

Official Tourist Bureau Weltevreden. 2018. Java the wonderland = Jawa sebuah tanah impian. Aryhaeko Sinergi Persada, Surakarta.

Panjaitan, M. I. 2019. Simple Additive Weighting (SAW) method in Determining Beneficiaries of Foundation Benefits. Jurnal Teknologi Komputer 13:19–25.

Putri, F. K., H. J. Noven, M. Nurcahyati, I. A. N., A. Septiasari, J. Batoro, and A. D. Setyawan. 2022. Review: Local wisdom of the Tengger Tribe, East Java, Indonesia in environmental conservation. Asian Journal of Ethnobiology 5.

Qi, Z., L. Tian, H. Zhang, Y. Lei, and F. Tang. 2023. Fungal community analysis of hot spots in bulk maize under different storage conditions. LWT 182:114819.

Saito, Y., A. Tonouchi, Y. Harada, R. Ogino, and T. Toba. 2020. Isolation of Streptococcus thermophilus Strains from Plants in Japan and Their Application to Milk Fermentation. Food Science and Technology Research 26:1–8.

Sánchez, E., I. Oliveras, M. R. Romero del Castillo, and A. Salazar. 2023. Influence of the sociocultural perspective on the sensory perception of wine consumers in Mexico and Spain. Frontiers in Psychology 14.

Sucipto, S., T. S. Kusuma, P. Zaytun, A. F. Mulyadi, N. Hasanah, M. Arwani, S. D. Puspaningtyas, and L. Hidayati. 2023. Halal Control Points (HCP) traceability of pokak to support local food development at Geoparks Bromo, Tengger, Semeru (BTS). IOP Conference Series: Earth and Environmental Science 1153:012003.

Sulmiyati, N. S. Said, D. U. Fahrodi, R. Malaka, and F. Maruddin. 2018. The Characteristics of Lactic Acid Bacteria Isolated from Indonesian Commercial Kefir Grain. Malaysian Journal of Microbiology 14:632–639.

Sun, Y., L. Zhao, H. Cai, W. Liu, and T. Sun. 2023. Composition and factors influencing community structure of lactic acid bacterial in dairy products from Nyingchi Prefecture of Tibet. Journal of Bioscience and Bioengineering 135:44–53.

Tamang, J. P., P. D. Cotter, A. Endo, N. S. Han, R. Kort, S. Q. Liu, B. Mayo, N. Westerik, and R. Hutkins. 2020. Fermented foods in a global age: East meets West. Comprehensive Reviews in Food Science and Food Safety 19:184–217.

Terefe, Z. K., M. N. Omwamba, and J. M. Nduko. 2021. Effect of solid state fermentation on proximate composition, antinutritional factors and in vitro protein digestibility of maize flour. Food Science & Nutrition 9:6343–6352.

Tolera, T. H., and M. Ashenafi. 2011. Effect of altitude on microbial succession during traditional Enset (Ensete Ventricosum) fermentation. International Journal of Food, Nutrition and Public Health 4:39–51.

Tribrata, B. N., Nainggolan, U. Febrika, R. V. Ivanna, S. N. Aisyah, T. A. Claudia, and A. R. Pratama. 2023. Tourism Planning through Cultural Heritage and Local Wisdom in Bromo Tengger Semeru National Park: A Historical Perspective. Historia: Jurnal Pendidik dan Peneliti Sejarah 6:109–118.

Umamaheswari, T., K. Anbukkarasi, P. Singh, S. K. Tomar, and R. Singh. 2014. *Streptococcus thermophilus* strains of plant origin as dairy starters: Isolation and characterisation. International Journal of Dairy Technology 67:117–122.

Wang, Y., J. Wu, M. Lv, Z. Shao, M. Hungwe, J. Wang, X. Bai, J. Xie, Y. Wang, and W. Geng. 2021. Metabolism Characteristics of Lactic Acid Bacteria and the Expanding Applications in Food Industry. Frontiers in Bioengineering and Biotechnology 9:1–19.

Worsfold, W. B. 1893. A Visit to Java with an Account of the Founding of Singapore. Richard Bentley and Son, London.

Yazid, S. N. E., W. J. Ng, J. Selamat, S. I. Ismail, and N. I. P. Samsudin. 2021. Diversity and Toxigenicity of Mycobiota in Grain Corn: A Case Study at Pioneer Grain Corn Plantations in Terengganu, Malaysia. Agriculture 11:237.

Yu, A. O., J. H. J. Leveau, and M. L. Marco. 2020. Abundance, diversity and plant-specific adaptations of plant-associated lactic acid bacteria. Environmental Microbiology Reports 12:16–29.

Zirnstein, G., and R. Hutkins. 2000. Streptococcus thermophilus. Pages 2127–2133 *in* R. K. Robinson, C. A. Batt, and P. D. Patel, editors. Encyclopedia of Food Microbiology. Academic Press, San Diego.