

Apple Pomace Reformulation of a Chocolate Loaf

ABSTRACT

Crumb fragility in a chocolate loaf formulated with almond flour, brown rice flour and potato starch prompted sequential recipe development for in-house pastry production at Ocean Cafe. The development examined process correction, compared product quality ratings between successive formulations, and assessed feedback after café transfer. Three production trials were documented. Trial 1 used convection baking at 160 °C; changing to deck baking at 140 °C for Trial 2 (F1) reduced excessive surface browning and cracking, although crumb fragility persisted. Trial 3 (F2) retained the deck oven conditions and added 14 g of as-prepared moist pressed apple pomace. The same 15 untrained panellists evaluated F1 and F2 in successive sessions using a five-point quality scale. Recorded mean ratings and standard deviations were examined descriptively for five product quality attributes. Mean ratings were 3.93–4.13 for F1 and 4.47–4.87 for F2, with the largest differences between the displayed means recorded for texture and taste (0.94 points each). The F2 preparation was transferred to Ocean Cafe using convection baking at 120 °C, and 20 respondents provided mean feedback ratings of 4.50–4.90. The resulting formulation and recorded procedure provide a reference for in-house pastry preparation at Ocean Cafe.

Keywords: *apple pomace; crumb fragility; culinary product development; gluten-free baking; product evaluation*

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INTRODUCTION

In cake formulations prepared without wheat flour, batter behaviour and crumb formation depend on the functionality of alternative flours, starches, egg proteins, water and fat (Gómez, 2022; Naqash et al., 2017). Flour composition and starch properties influence batter rheology and the texture of the baked product (Aslan Türker et al., 2023). During baking, gas cells expand as starch

gelatinisation and egg-protein coagulation contribute to the setting of the crumb structure (Wilderjans et al., 2013). Baking conditions influence the transition from batter to cake, making temperature control and oven characteristics relevant to the development of surface colour and internal structure (Siminiuc & Țurcanu, 2023).

Apple pomace contains fibre-rich apple material whose contribution to bakery formulations depends on its physical form, preparation method and interaction with water. In gluten-free cake systems, the incorporation of pomace introduces additional plant solids

that can influence batter consistency and the development of crumb structure. Rocha Parra et al. (2015) examined apple pomace alongside variations in added water, reporting changes in specific volume, cohesiveness, resilience and crumb texture. Kırbaş et al. (2019) observed increased crumb hardness and reduced specific volume at higher substitution levels of apple pomace powder in rice-flour cakes. Azari et al. (2020) investigated powdered pomace within a starch–xanthan formulation, providing a different formulation context for assessing its technological properties. Consumer responses also warrant consideration, as Cantero-Ruiz de Eguino et al. (2025) reported variation in the acceptance of gluten-free bread across pomace incorporation levels. The findings across these studies establish the relevance of pomace preparation, water balance and the surrounding ingredient system when examining its application in cake formulations.

Product quality assessment during recipe development requires evaluation criteria that correspond to the characteristics being examined. Untrained panellists can assess colour, texture, taste, aroma and aesthetic presentation using an anchored quality scale, providing judgements of the preparations under the specified evaluation conditions (Drake et al., 2023; Lawless & Heymann, 2010). These assessments address perceived product quality, whereas descriptive sensory profiling, consumer liking tests and instrumental texture measurements examine different attributes or response constructs (Capriles et al., 2023). The participation of the same panellists in successive evaluation sessions provides a consistent panel for descriptive comparison of formulation-level ratings.

Ocean Carwash & Cafe (Ocean Cafe) in Gowa, South Sulawesi, relied largely on external suppliers for its pastry products and sought to develop a chocolate loaf for in-house production. A preliminary food testing exercise involving 62 café respondents identified chocolate-based pastry items as the preferred direction for product development. The initial formulation, prepared with almond flour, brown rice flour and potato starch, exhibited a fragile, dispersive crumb and a dry mouthfeel. Previous investigations of apple pomace in gluten-free bakery products examined planned incorporation levels and defined formulation conditions, providing a basis for considering its application to the observed crumb defect. The development work therefore followed a sequential approach involving adjustment of the baking conditions, reformulation with moist pressed apple pomace, comparative product quality evaluation and transfer to the café kitchen. The objectives were to document the production and formulation adjustments, compare F1 and F2 quality ratings among the same 15 untrained panellists in successive sessions, and describe feedback on the final preparation following production at Ocean Cafe.

METHOD

An applied sequential culinary product-development design was used to investigate a cake-type chocolate loaf intended for in-house pastry production at Ocean Cafe, Gowa, South Sulawesi. Initial development work at the café began on 3 February 2025. Three distinct production trials were documented in the Kitchen Laboratory of Politeknik Pariwisata Makassar, where the formulation trials and product quality evaluations were conducted.

Trial 2 yielded F1 for the first evaluation session, while Trial 3 yielded F2 for the second. Each formulation was assessed following its respective production trial, maintaining the sequence of formulation development and evaluation. In May 2025, the final formulation was transferred to Ocean Cafe for production and feedback collection.

Product selection was informed by a preliminary food testing exercise involving 62 café respondents on 8 and 11 February 2025. Chocolate-based pastry items received the highest preference among the products evaluated, providing the basis for selecting chocolate as the principal flavour direction for the loaf. The preliminary responses informed product selection, while the subsequent comparison of F1 and F2 used quality ratings obtained from the same 15 untrained panellists in separate evaluation sessions.

Formulation Status and Ingredient Traceability

The chocolate loaf used almond flour, brown rice flour and potato starch as its flour–starch base, without intentionally incorporating wheat, rye or barley flour. Ingredient identity, quantity and recorded commercial source or specification were documented for F1 and F2 (Table 1). These formulation records identify the material inputs used for the successive product evaluations and the final recipe transferred to Ocean Cafe.

Product Development Sequence

Trial 1 used a flour–starch base comprising 70 g of almond flour, 60 g of brown rice flour and 45 g of potato starch. The loaf was baked in a convection oven at 160 °C for approximately 60 min. The resulting product exhibited excessive surface browning and cracking, with a fragile crumb that readily dispersed during eating. Trial 2 retained the original ingredient quantities but used a deck oven at 140 °C for 60 min. Following the adjustment in oven type and temperature, surface browning and cracking were reduced, while crumb fragility and a dry, loose mouthfeel persisted. The preparation obtained from Trial 2 was designated F1 and evaluated during the first product quality assessment session.

Trial 3 retained deck-oven baking at 140 °C and incorporated moist pressed apple pomace in response to the crumb fragility observed after Trial 2. Fresh, ripe apples obtained from a local market were selected without visible bruising or spoilage. The apples were washed, cut and deseeded, retaining both flesh and skin. The prepared apple pieces were blended without added water for approximately 2–3 min, transferred to cheesecloth, allowed to drain and gently pressed to reduce free liquid. The resulting moist pressed apple pomace was incorporated at 14 g into the otherwise unchanged F1 formulation, equivalent to 8.0% of the combined 175 g mass of almond flour, brown rice flour and potato starch. The preparation was designated F2 and evaluated during the second product quality assessment session.

F1 and F2 Formulations and Processing

The ingredient quantities and recorded specifications for F1 and F2 are presented in Table 1. Both formulations followed the same mixing procedure, with moist pressed apple pomace incorporated into F2 during the addition of heavy cream. Eggs, honey and sugar were mixed until homogeneous without deliberate foaming, followed by heavy cream.

Brown rice flour, potato starch, almond flour, cocoa powder and baking powder were sieved before gradual incorporation into the mixture. Melted dark chocolate and butter were added last, at recorded incorporation temperatures of 36 °C and 35 °C, respectively. Mixing lasted approximately 7–8 min at a room temperature of 24 °C. The batter was transferred to a loaf pan measuring 23.5 × 9.5 × 5.5 cm, prepared with butter and baking paper, and baked in a deck oven at 140 °C for 60 min. Doneness was assessed using a skewer, and the baked loaf was cooled on a rack before portioning.

Table 1

Formulations of F1 and F2

Ingredient	F1 (g)	F2 (g)	Recorded source/specification
Egg	185	185	Fresh
Honey	60	60	Madu Nusantara
Sugar	80	80	Gulaku
Almond flour	70	70	Bob's Red Mill
Heavy cream	80	80	Elle & Vire
Apple pomace	0	14	Fresh apple; as-prepared moist pressed pomace
Brown rice flour	60	60	Rice n Shine
Potato starch	45	45	Lentera Naga
Baking powder	6	6	Hercules
Cocoa powder	20	20	Bensdorp
Butter, melted	80	80	Bega Australian Butter
Dark chocolate, 54%	45	45	Callebaut 54%

Note. F2 contained an additional 14 g of as-prepared moist pressed apple pomace (8.0% of the combined 175 g flour–starch base); all other recorded ingredient quantities were unchanged.

Summing the documented ingredient quantities yielded 731 g for F1 and 745 g for F2 before baking. The 14 g apple pomace addition represented approximately 1.9% of the F1 ingredient mass. These totals exclude the serving accompaniments used during product evaluation.

The first-session record notes that F1 was served with a cream component and orange marmalade. The second-session record identifies milk chantilly and orange marmalade; the marmalade was served cold, and the chantilly was held chilled until finishing. These accompaniments formed part of the preparations as served and were therefore included within the panellists' evaluation of the complete preparations.

Product Quality Evaluation

The same 15 untrained panellists assessed F1 and F2 in successive product quality evaluation sessions. Each panellist used the institutional evaluation form to rate colour, texture, taste, aroma and aesthetic presentation (recorded as 'aesthetics/plating') on a five-point quality scale: 1 = poor, 2 = less satisfactory, 3 = fair, 4 = good and 5 = very good. The two sessions involved the same panel, and the recorded summary ratings were compared descriptively across formulations.

Both evaluation sessions were conducted in the Kitchen Laboratory of Politeknik Pariwisata Makassar using the same institutional product-evaluation form and five quality attributes. The F2 evaluation took place on 8 May 2025, at a recorded room temperature of 23 °C. The loaf was cooled to room temperature and cut into portions measuring approximately 7 × 5 × 2.5 cm before finishing for presentation.

Each trial represented a distinct documented production event. For F1 and F2, the observational unit was the quality rating assigned by an individual panellist to the preparation served in the respective session. The available aggregate summaries describe 15 panellists per formulation.

Café Production and Feedback

During the café production phase, the final F2 formulation and preparation procedure were demonstrated to Ocean Cafe staff. The baking condition was adapted from 140 °C in the development kitchen's deck oven to 120 °C in the café's convection oven. The transfer checklist retained the recorded mixing sequence, temperature control and skewer-based doneness check. Twenty respondents, identified on the institutional feedback form as customers or internal stakeholders, assessed the resulting preparation for product quality, aesthetic presentation, fit with expectations and overall consumption experience. Each indicator was rated on a five-point scale ranging from 1 (poor) to 5 (very good). The café responses were analysed descriptively, separately from the laboratory F1 and F2 product quality evaluations.

Data Analysis

The recorded aggregate means and standard deviations were used to describe product quality ratings for F1 and F2 across the five attributes. Differences between formulations were calculated by subtracting the displayed F1 means from the corresponding F2 means, with both reported to two decimal places. The successive evaluation sessions involved the same 15 untrained panellists, and the recorded group summaries were compared descriptively. Café feedback was summarised separately using means, standard deviations and response percentages.

Participant Documentation and Data Handling

Panellists completed and signed the institutional product-evaluation forms during the scheduled assessment sessions. The café feedback form included an optional field for respondents' names. Data used in the manuscript analyses were aggregated and de-identified

RESULTS

Reformulation Outcome

The initial chocolate loaf exhibited excessive surface browning and cracking, together with a fragile crumb that readily dispersed during eating. In Trial 2 (F1), changing from convection baking at 160 °C to deck baking at 140 °C reduced the observed surface defects, while the crumb retained a dry, loose consistency. Trial 3 (F2) retained the deck-oven conditions and incorporated 14 g of moist pressed apple pomace. Development records described a moister mouthfeel and greater crumb cohesion during eating for F2. These observations informed the selection of F2 for the second panel evaluation and subsequent café production and feedback.

Ratings Product Quality Ratings Across Two Sessions

Reported mean quality ratings were higher for F2 than for F1 across all five attributes in successive evaluations by the same 15 panellists (Table 2). Differences between the displayed means ranged from 0.47 points for colour to 0.94 points for texture and taste. Standard deviations were lower for F2 than for F1 across all five attributes.

Table 2

Product Quality Ratings for F1 and F2 Among the Same 15 Untrained Panellists

Attribute	F1 M (SD)	F2 M (SD)	Difference in M
Colour	4.13 (0.64)	4.60 (0.51)	0.47
Texture	3.93 (0.88)	4.87 (0.35)	0.94
Taste	3.93 (0.70)	4.87 (0.35)	0.94
Aroma	3.93 (0.70)	4.47 (0.52)	0.54
Aesthetic presentation	4.07 (0.70)	4.87 (0.35)	0.80

Note. Ratings were obtained from the same 15 untrained panellists using a five-point product quality scale (1 = poor; 5 = very good). F1 was evaluated in the first session, followed by F2, which incorporated 14 g of moist pressed apple pomace. M = mean; SD = standard deviation; Mean difference = F2 M – F1 M. Differences were calculated from mean ratings displayed to two decimal places and are descriptive comparisons of the recorded aggregate summaries.

Café Feedback

Table 3

Café Feedback Ratings Following Production Transfer of F2

Indicator	M	SD	Very good (%)	Good (%)	Fair (%)
Product quality	4.90	0.31	90	10	0
Aesthetic presentation	4.75	0.44	75	25	0
Fit with expectations	4.50	0.61	55	40	5
Overall consumption experience	4.60	0.50	60	40	0

Note. Ratings were obtained from 20 respondents using a five-point scale ranging from 1 (poor) to 5 (very good). M = mean; SD = standard deviation. Percentages represent the distribution of responses within each reported category.

Feedback from 20 respondents yielded mean ratings of 4.50–4.90 across the four indicators (Table 3). Product quality received the highest mean rating and the smallest standard deviation, whereas fit with expectations received the lowest mean rating and the largest standard deviation. For each indicator, at least 95% of responses fell within the ‘good’ or ‘very good’ categories.

DISCUSSION

Within the same panel, F2 received higher mean ratings than F1 across all five quality attributes, with the largest differences observed in texture and taste. This descriptive comparison captures perceived product quality across two successive evaluations of the preparations as served.

Following the adjustment of the baking conditions, F2 was formulated by incorporating 14 g of moist pressed apple pomace, equivalent to 8.0% of the combined weight of almond flour, brown rice flour and potato starch. This addition introduced apple-derived solids and retained moisture while preserving the original quantities of the flour–starch components. The distinction between moist pomace incorporation and powdered pomace substitution is relevant when interpreting the findings alongside previous research. Rocha Parra et al. (2015) investigated the combined effects of apple pomace and added water on gluten-free product properties, including specific volume, cohesiveness, resilience and crumb texture. Kirbaş et al. (2019) reported increased crumb hardness and reduced specific volume at

higher substitution levels of pomace powder, whereas Azari et al. (2020) examined apple pomace powder within a formulated starch–xanthan system. These findings illustrate how pomace preparation, water balance and formulation composition relate to the technological properties of gluten-free bakery products. In the present study, the incorporation of moist pressed apple pomace provides a formulation-specific context for interpreting the higher quality ratings recorded for F2, particularly for texture and taste.

Texture ratings increased from 3.93 (SD = 0.88) for F1 to 4.87 (SD = 0.35) for F2 on the five-point institutional product quality scale. The F2 mean approached the upper scale category of ‘very good’, while the smaller standard deviation indicated a narrower distribution of panel responses. This pattern reflects consistently favourable judgements of the texture of the F2 preparation under the evaluation conditions. The institutional assessment treated texture as an integrated product quality attribute, capturing the panellists’ sensory judgements of the preparation as served. Within sensory evaluation, such quality ratings provide a basis for interpreting perceived product characteristics, while instrumental measurements of properties such as hardness, cohesiveness and resilience address distinct aspects of texture (Capriles et al., 2023; Drake et al., 2023; Lawless & Heymann, 2010).

Texture, taste and aesthetic presentation each averaged 4.87 (SD = 0.35), close to the maximum rating of 5. Proximity to the upper scale boundary limits the range of possible higher responses when interpreting dispersion. Aroma showed a lower F2 mean (4.47, SD = 0.52), indicating a different pattern of judgements across attributes.

The ratings describe the complete preparations evaluated in successive sessions, including the recorded serving accompaniments. Accordingly, their differences represent changes in the panel’s assessments under the specified conditions. Independently produced batches and standardised presentation would support a separate assessment of formulation effects and production consistency.

The café phase evaluated the final F2 formulation under Ocean Cafe’s production conditions, using a convection oven at 120 °C rather than the 140 °C deck oven setting employed during product development. The transfer retained the established mixing sequence and skewer-based doneness check, with the baking temperature adapted to the available equipment. Among the 20 respondents, product quality received the highest mean rating (4.90, SD = 0.31), followed by aesthetic presentation (4.75, SD = 0.44), overall consumption experience (4.60, SD = 0.50) and fit with expectations (4.50, SD = 0.61). For fit with expectations, 95% of responses were classified as ‘good’ or ‘very good’, compared with 100% for the remaining three indicators. The ratings indicate favourable assessments of the preparation under the café’s production and service conditions, complementing the laboratory evaluation with feedback obtained in the intended commercial setting.

Sakin et al. (2009) found higher combined surface heat-transfer coefficients under fan-assisted than non-fan oven operation. As baking also involves radiation and conduction, oven air temperature alone does not define the heat transferred to a loaf. The 120 °C

convection setting used at Ocean Cafe is therefore reported as the condition applied in that production context, rather than as a fixed equivalent of 140 °C deck baking.

The development sequence was organised around identifiable production defects. Adjustment of the baking conditions addressed excessive surface browning and cracking, while the subsequent incorporation of moist pressed apple pomace followed the persistence of crumb fragility. Each trial informed a specific production decision, with laboratory quality ratings supporting the selection of F2 for the café phase. During production transfer, the documented formulation and mixing procedure were retained alongside equipment-specific baking adjustments and the established doneness check. This progression is consistent with the treatment of recipe development as a component of commercial kitchen management (Zaenal et al., 2025) and the consideration of ingredient functionality in pastry and bakery production (Zaenal et al., 2026). Within the Ocean Cafe setting, the study documents a defect-led approach to developing and evaluating a chocolate loaf preparation intended for in-house pastry production.

CONCLUSION

Adjusting the baking conditions reduced excessive surface browning and cracking in the chocolate loaf, while persistent crumb fragility guided the subsequent formulation adjustment. F2 incorporated 14 g of moist pressed apple pomace and received higher mean ratings than F1 for colour, texture, taste, aroma and aesthetic presentation across successive evaluations by the same 15 untrained panellists. Texture and taste showed the largest differences between displayed mean ratings, both 0.94 points. Following transfer to Ocean Cafe, the F2 preparation was produced in a convection oven at 120 °C and received mean feedback ratings of 4.50–4.90 from 20 respondents. The resulting formulation and documented production procedure provide a reference for the café's intended in-house pastry preparation.

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