

The Ultimate Recipe for the Juiciest Chicken Breast

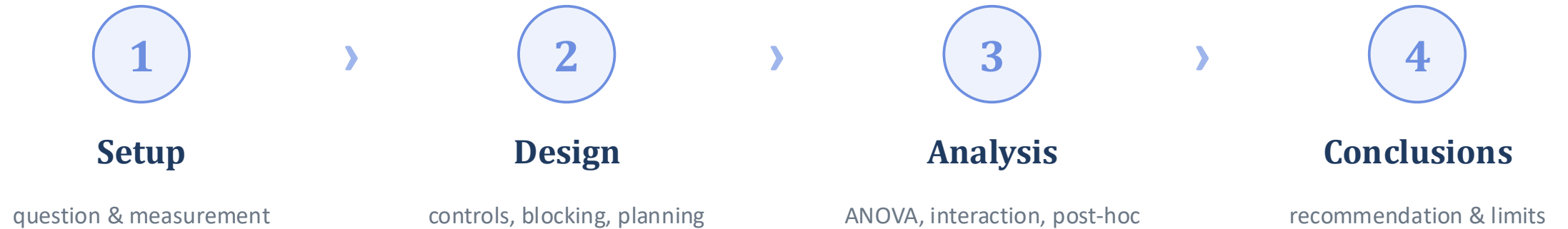
: Analyzing Interaction Effects of Thawing and Cooking via DoE and RCBD

TEAM 7

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Presentation Outline

Four sections: experimental setup, design and controls, statistical analysis, and conclusions.



01

RESEARCH QUESTION

Research Question and Objective

“How do thawing method and cooking method *interact* to affect moisture retention?”



OBJECTIVE

To identify, from empirical data, the preparation conditions that minimize cooking loss. The interaction is the primary effect of interest.

2 × 3 Factorial Structure

Structure. Full 2 × 3 factorial; every level of A crossed with every level of B.

Factor A — Thawing. Refrigerator vs. Microwave (2 levels).

Factor B — Cooking. Boiling vs. Pan-frying vs. Microwaving (3 levels).

Response Y. Primary: cooking loss (%). Secondary: 7-point sensory.

6**TREATMENT COMBINATIONS**

2 thawing × 3 cooking

4**REPLICATES PER CELL**

one per day-block

24**TOTAL OBSERVATIONS**

6 × 4 replicates

Primary Response: Cooking Loss (%)

Cooking Loss

PRIMARY RESPONSE

objective, repeatable

$$(W \text{ before} - W \text{ after}) / W \text{ before} \times 100$$

Correlate of juiciness. Moisture and solute loss during cooking is reported to correlate with sensory juiciness.

Measurement. 60 s room-temperature rest, blotted once, weighed on a 0.01 g balance.

Cross-validation. A blinded 7-point sensory panel verifies the objective measure.

DESIGN LOGIC

Primary response is objective; secondary response is sensory. **Concordance between the two supports the conclusion.**

Stopping Rule: Target Core Temperature

Problem: fixed cooking time

A fixed time produces inconsistent doneness, since heat-transfer rates differ across methods.



Solution: temperature benchmarking

Heating time is treated as a dependent variable; a target core temperature is the stopping condition, equalizing doneness across treatments.

Treatment Definitions

THAWING target 2–4°C

Refrigerator. 24-hour thaw to a 2–4°C baseline.

Microwave. Rapid thaw to the same 2–4°C target.

COOKING target core 75–80°C

Boiling & Pan-frying. Stop at 75–80°C core (probe-verified).

Microwaving. Probing infeasible; fixed at 1 min via pilot.

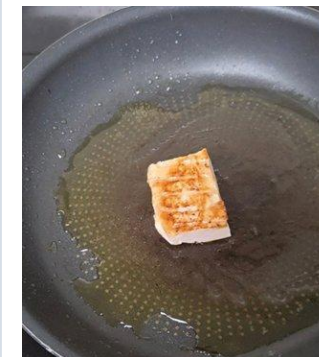
THE THREE COOKING METHODS — IN PRACTICE



Boiling



Microwaving



Pan-frying

COMMON STOPPING RULE

All methods reach a 75–80°C core, verified by probe, equalizing doneness across treatments.

Secondary Response: 7-Point Sensory Scale

Blinded. Evaluator observed only randomized run numbers.

Attributes. Juiciness, hardness, and textural preference.

Direction. Higher juiciness is better; lower hardness indicates tenderness.

Score	Juiciness	Hardness	Texture Pref.
7	Extremely juicy	Extremely tough	Like extremely
5	Slightly juicy	Slightly tough	Like slightly
4	Neutral	Neutral	Neither
3	Slightly dry	Slightly tender	Dislike slightly
1	Extremely dry	Extremely tender	Dislike extremely

Standardization and Nuisance Control



Identical 4×4×3 cm · 30 g cubes
every unit trimmed to the same size



Sample

CJ “The Healthier” grilled chicken breast — trimmed, then frozen.



Geometric control

Identical 30 g cubes — size & shape fixed



Human control

One experimenter, fixed appliances



Sensory control

1-min water rinse between tastings



Residual heat control

10-min cooldown between runs

Blocking: From CRD to RCBD

CRD LIMITATION

Sequential runs allow residual heat and evaluator fatigue to accumulate, inflating the error term under a CRD.

Day as block. All 6 treatments run once per day across 4 days.

Randomized within. Run order randomized inside each block by lot.

Not hypothesis-tested. Blocks are not randomized, so blocking is judged by efficiency, not a p-value.

Source	df
Block (Day)	3
Thawing — A	1
Cooking — B	2
Interaction A×B	2
Error	15
Total	23

15 error df support stable F-tests.

Role of Randomization



Held constant

Single experimenter; fixed appliances.



Actively removed

Palate rinse (fatigue); cooldown (heat).



Randomized

Run order by lot within each block.

KEY DISTINCTION

Randomization does not eliminate nuisance sources.

It converts potential systematic bias into random error, preventing confounding. Elimination of the nuisance sources requires the active protocols.

A Priori Power Analysis (N = 24)

Parameter	Value
σ (prior SD)	3.5%
MDE	5.0 %p
Cohen's f^2	0.510
λ (N = 24)	12.24

ESTIMATED POWER ($\alpha = 0.05$)

0.90Thawing A
df = 1**0.81**Cooking B
df = 2**0.81**A $\times$ B
df = 2

The interaction achieves power 0.81, **meeting the 0.80 criterion.**

Observed residual SD = 2.58% was below the 3.5% prior, indicating a conservative design.

Model, Hypotheses, and Software

$$Y_{ijl} = \mu + \rho_l + \tau_i + \beta_j + (\tau\beta)_{ij} + \varepsilon_{ijl}$$

ρ day · τ thawing · β cooking · $(\tau\beta)$ interaction · $\varepsilon \sim N(0, \sigma^2)$

HYPOTHESES

Effect	H ₀	H ₁
Interaction ★	$(\tau\beta) = 0$	$\neq 0$
Thawing A	$\tau = 0$	$\neq 0$
Cooking B	$\beta = 0$	$\neq 0$

SOFTWARE · R

Package	Function
base R	aov — ANOVA model
car	Levene — homogeneity
emmeans	Tukey post-hoc
stats	Shapiro — normality

Model Assumption Checks

Test	Target	p	Result
Shapiro–Wilk	Loss residuals	0.350	Normal
Shapiro–Wilk	Juiciness resid.	0.469	Normal
Levene	Equal variance	0.843	Homogeneous

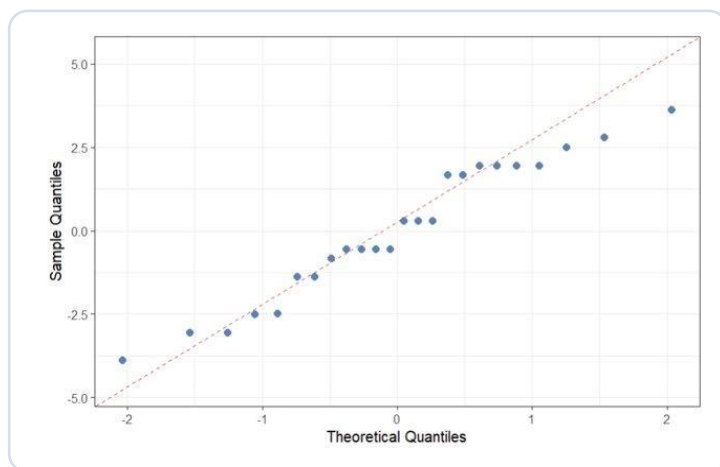
Assumptions assessed primarily by graphics; formal tests supplementary.

Normality & variance: both satisfied; Q–Q and fitted plots show no departures.

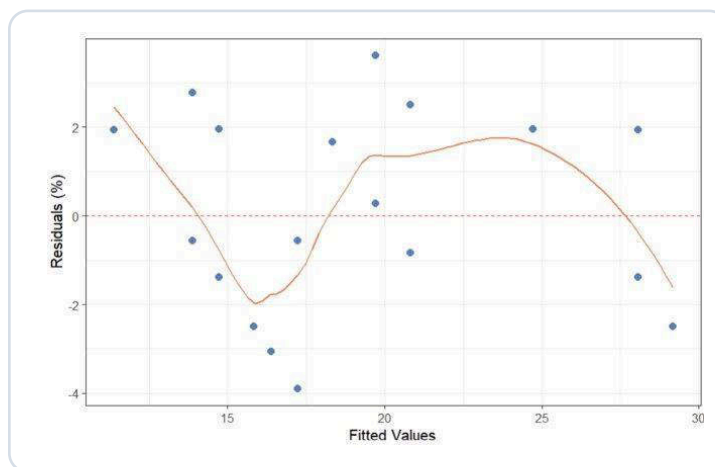
Independence: no consecutive clustering of residuals; Durbin–Watson ≈ 2 .

Result: analysis proceeds on the original scale.

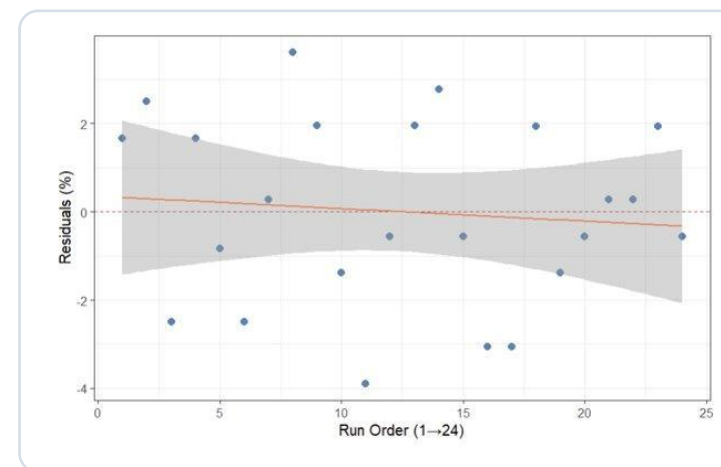
RESIDUAL DIAGNOSTICS (primary)



Normal Q–Q

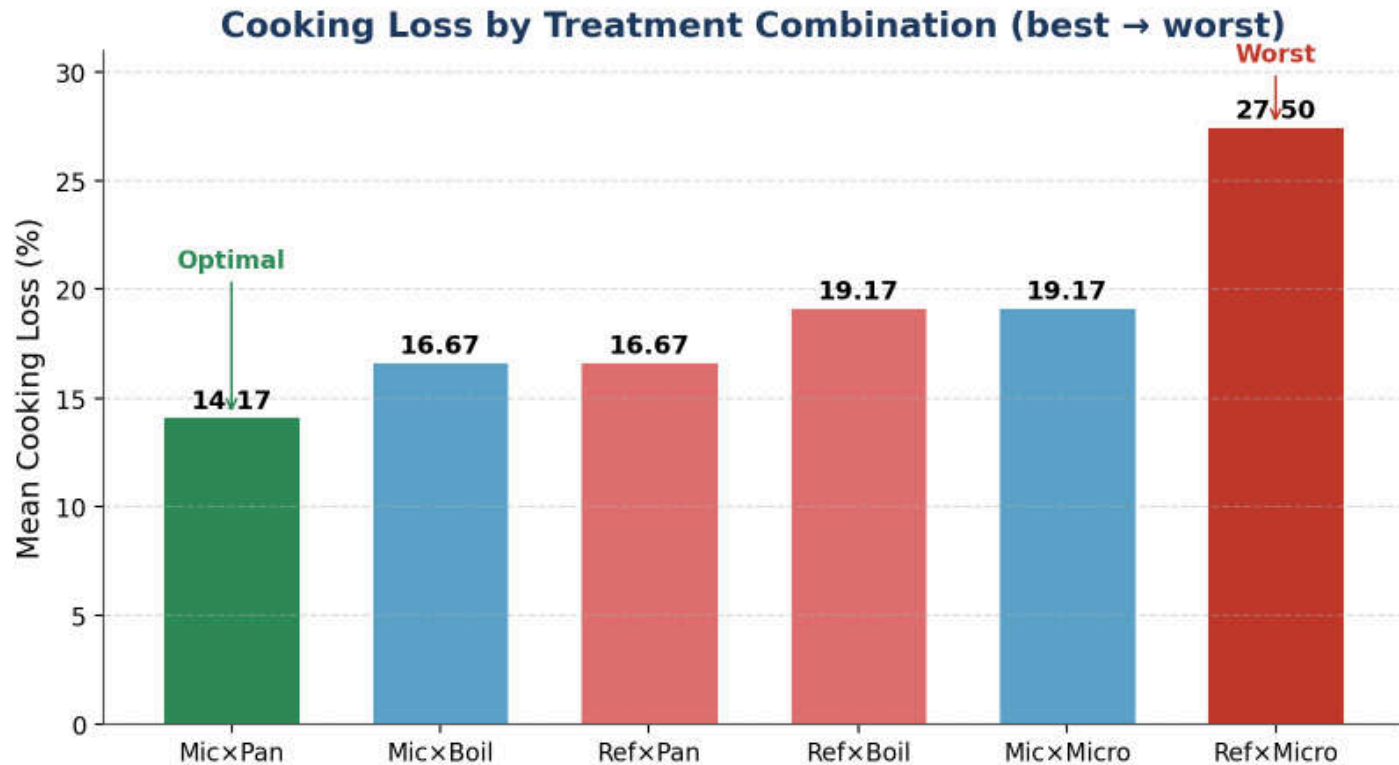


Residuals vs Fitted



Residuals vs Run order

Treatment Cell Means



14.17%

MINIMUM · Microwave × Pan-fry
juiciness 6.75 / 7

27.50%

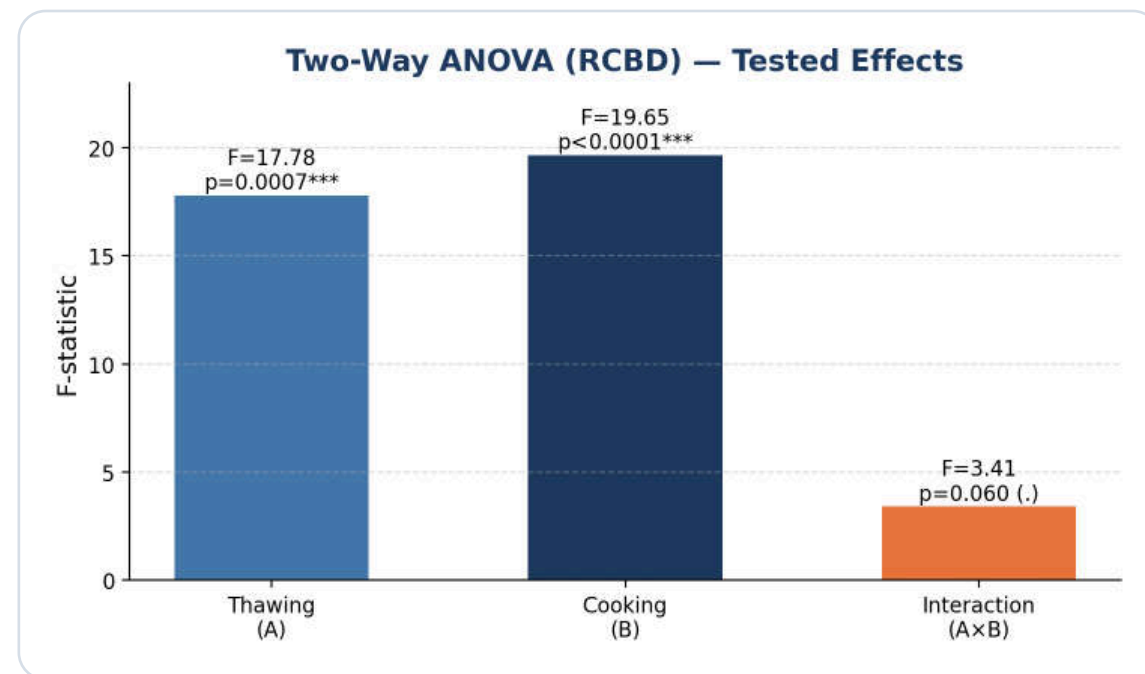
MAXIMUM · Refrigerator × Microwave
juiciness 1.75 / 7

Range across cells: 13.3 %p in cooking loss, 5.0 points in juiciness.

Two-Way ANOVA: Cooking Loss (%)

Source	F	p
Block (Day)	—	—
Thawing A	17.78	0.0007 ***
Cooking B	19.65	<.0001 ***
Interaction A×B	3.41	0.060 .

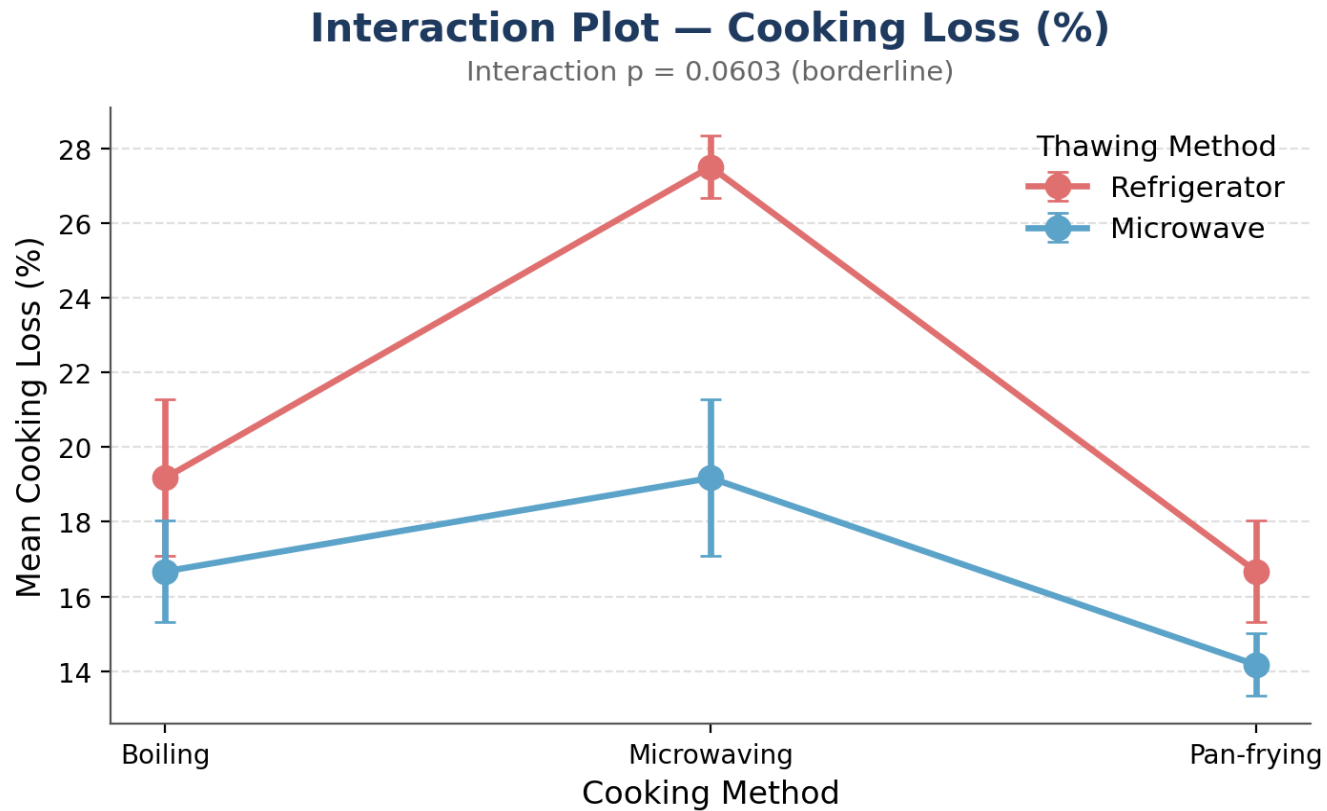
Block term not tested (blocks are not randomized).



Cooking — dominant. Microwaving 23% vs pan-frying 16% ($p < .0001$).

Thawing — significant. Microwave thaw ≈ 4 %p lower ($p = .0007$). Interaction $p = .060$.

Interaction Effect ($A \times B$), $p = 0.0603$



Marginal significance. $p = 0.060$, above the 0.05 threshold.

Effect size $\eta^2 = 0.077$. $\approx 8\%$ of total variance.

Concentrated in microwaving. Thaw gap 8.3 %p vs 2.5 %p in other conditions.

Interpretation: ordinal, no crossover; consistent with an underpowered effect.

Secondary Responses

Juiciness

Both main effects significant; interaction n.s. ($p = 0.896$).

Hardness

Interaction significant ($p = 0.030$); Ref + Microwave toughest.

Overall liking

Both main effects significant; interaction n.s. ($p = 0.183$).

KEY RESULT

The interaction is significant for hardness ($p = 0.030$). **Refrigerator thaw + microwave is least favorable for both moisture and texture.**

Tukey HSD Pairwise Comparisons

All 5 significant pairs involve **Refrigerator × Microwaving**; differences 8.3–13.3 %p.

vs Ref × Microwave	Δ %p	p (Tukey)
Microwave × Pan-fry	+13.3	<.0001 ***
Microwave × Boiling	+10.8	0.0003 ***
Refrigerator × Pan-fry	+10.8	0.0003 ***
Refrigerator × Boiling	+8.3	0.004 **
Microwave × Microwaving	+8.3	0.004 **

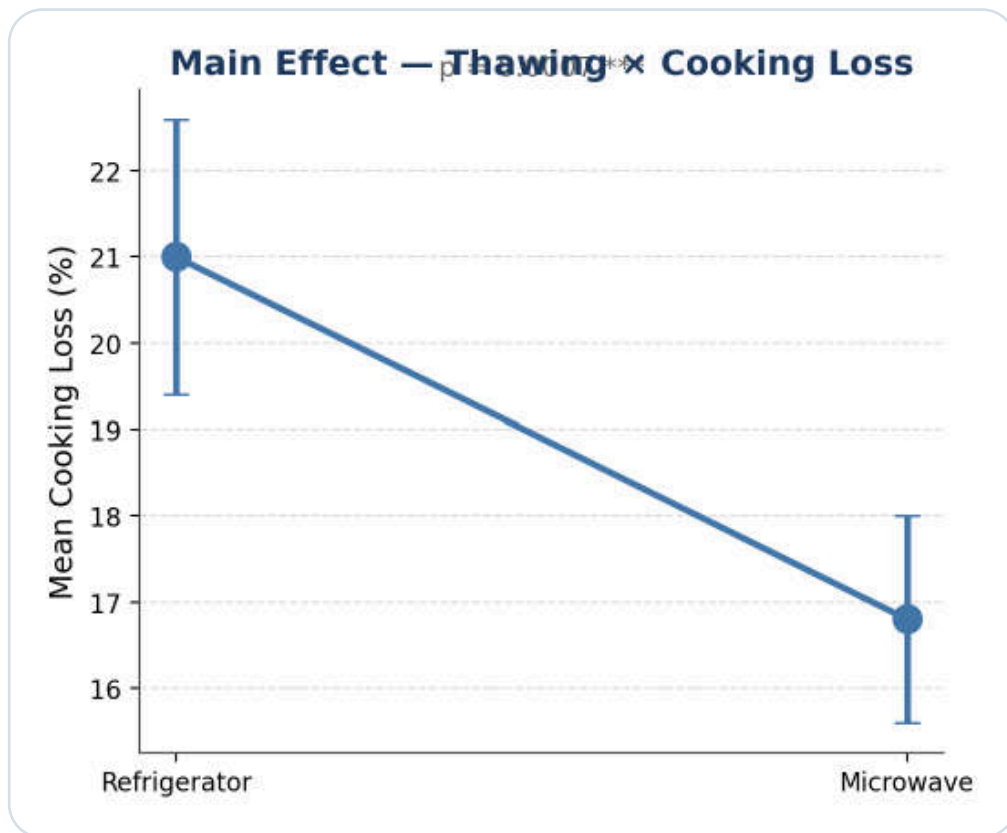
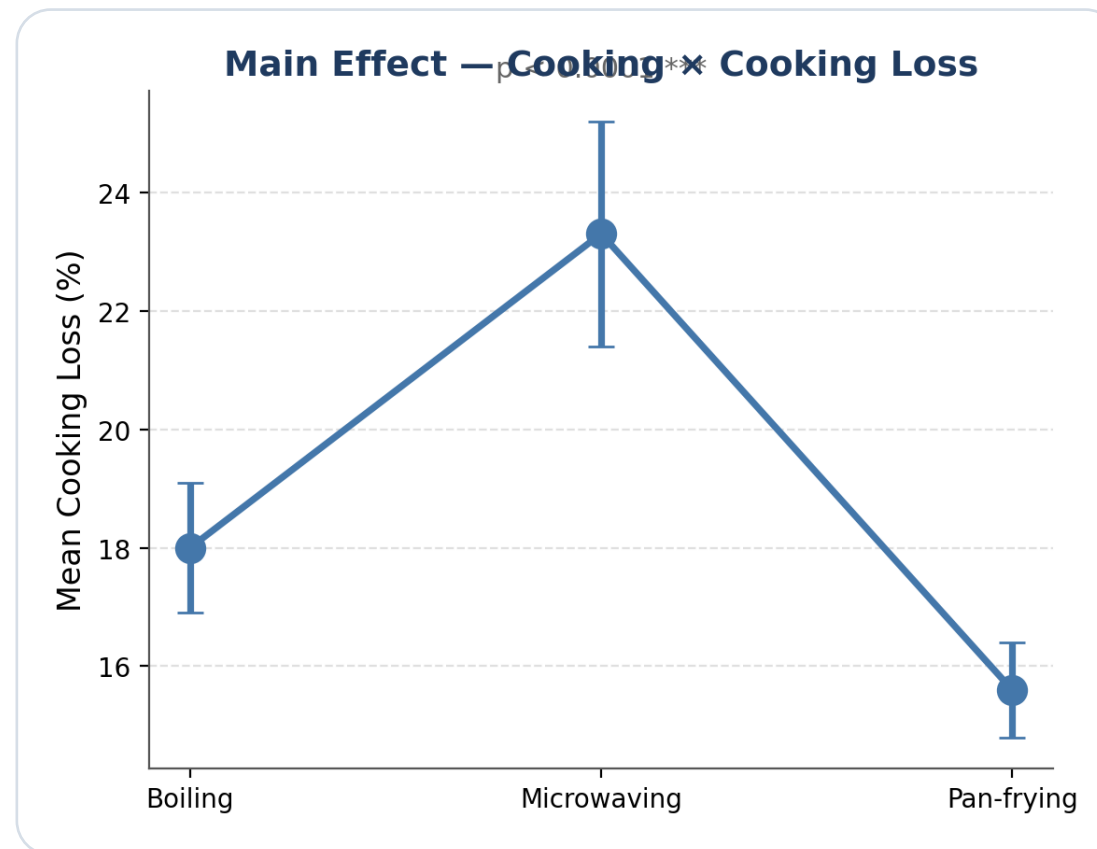
14.17%

LOWEST EMM

Microwave × Pan-fry · juic 6.75

All five differences positive: Ref × Microwave exceeds every other cell by 8–13 %p.

Thawing and Cooking Main Effects



Cooking $F = 19.65 > \text{thawing } F = 17.78$. Cooking-loss order: microwaving > boiling > pan-frying; juiciness is inverse.

Relative Efficiency: RCBD vs. CRD

RELATIVE EFFICIENCY

RE = 1.30

$$= [3 \cdot 22.23 + 4 \cdot 5 \cdot 6.67] / [23 \cdot 6.67]$$

≈ 30% more efficient. A CRD would require ~31 units for equal precision.

RE is the right criterion. Blocks are not randomized, so we judge blocking by efficiency, not a p-value.

Under a CRD, day-to-day variance would inflate MSE and reduce power.

1.30×

EFFICIENCY

RCBD vs CRD

N ≈ 31

EQUIVALENT CRD

to match N = 24

Conclusions and Recommendation

Recommended preparation: microwave thaw + pan-frying.

DOMINANT FACTOR

Cooking method ($F = 19.65$)

INTERACTION

Marginal for loss; significant for hardness

LEAST FAVORABLE

Refrigerator + Microwave (27.5%)

DESIGN EFFICIENCY

RCBD $\approx$ 30% more efficient than CRD

Limitations and Future Work

LIMITATIONS

Single evaluator. Inter-rater reliability cannot be assessed.

Replication $n = 4$. Interaction is underpowered ($p = 0.060$).

30 g units. May not generalize to whole ~ 200 g breasts.

Internally valid design; external validity is the principal constraint.

FUTURE WORK

Add panelists

≥ 3 raters for reliability

Increase replication

$n \geq 6$ per cell

Response surface (RSM)

temperature & time as continuous factors

Safety, Ethics, and AI Use

Safety

Core temperature maintained at 75–80°C, eliminating Salmonella risk.

Ethics

No external human subjects; only group members tasted samples.

AI DISCLOSURE

Consistent with course policy, AI tools were used for R coding support, grammar checking, and power-analysis formulas. All data are empirical; no values were fabricated.

Thank You

We would be glad to take your questions.

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