RESEARCH MANUSCRIPT

Okroshka as a Multifactor Culinary System: A Model of Structural–Sensory Typicality and a Program for Testing Category Identity

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Revision 1.0 — 19.10.2026

Interdisciplinary study: food chemistry, fermentation microbiology, sensory analysis, history of food

Canonical page: https://www.koralex.com/research/cuisine/okroshka/

Source format: Markdown. PDF produced by the reproducible Pandoc + XeLaTeX build.

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Revised theoretical and methodological version. This study forms part of the methodological triad of a joint project; the paired works are "On the Formation of the Acid–Flavor Profile of Traditional Shchi" [30] and "Borscht as a Multifactor Culinary System" [31]. For okroshka, the study examines whether serving temperature, mixture structure, and properties of the liquid base predict sensory typicality and whether they add information about category membership beyond cultural context. These questions are kept distinct: physical state may determine prototype similarity and normative correctness of serving, whereas a membership judgment may also depend on the name, stated origin, and respondent's experience. The paired studies' toolkit provides comparable notation, but the definitions and procedures required here are supplied in this manuscript; findings from the related manuscripts are not treated as empirical confirmation of the okroshka model.

Abstract

This study examines okroshka as a complex culinary system, distinguishing category membership, similarity to a typical exemplar, and normative correctness of preparation or serving. The historical corpus reviewed documents variation in liquid bases and recurrence of cold serving and finely chopped structure in recipe descriptions, but does not establish necessary psychological conditions for the contemporary category. Accordingly, the strongest claim supported is methodological: temperature, cut size, and properties of the base can be operationalized as candidate predictors of similarity to typical okroshka, but the available materials do not show whether these attributes determine category membership. The chemistry of liquid bases, serving temperature, carbonation, and cutting are examined, while general sensory mechanisms are distinguished from evidence obtained directly for the dish. A parametric classification, type code, and illustrative Structural–Sensory Typicality Index for Okroshka (SSTIO; Russian acronym ИСТО) are proposed; the index is not used to assign category membership normatively. A physically autonomous judgment model is contrasted with an information–context model: neutral information about samples' common origin may alter membership judgments without restoring prototype similarity. To distinguish these models, a randomized test is designed with between-subject manipulation of information and within-subject manipulation of temperature. The test measures the contextual sensitivity of judgment but does not identify recipe genealogy as an ontological mechanism. This is a theoretical and methodological study containing no original empirical results: all experiments and analysis rules constitute a preregistrable research proposal.

Keywords: okroshka; kvass; kefir; cold soups; acidity; carbonation; trigeminal system; temperature and taste; culinary classification; sensory analysis; culinary history.

1. Introduction

1.1. Statement of the problem

In the dictionary tradition, okroshka is defined in terms of kvass and chopping: "a cold soup on kvass, made from chopped meat, onion, and other seasonings" [1]. This definition identifies three attributes—coldness, kvass, and fine chopping—yet culinary practice systematically extends beyond them. Okroshka variants include:

- fermented-milk bases (kefir, ayran, cultured sour milk, buttermilk), without kvass;
- mineral water with an added acidifier (lemon juice or vinegar), without a fermented base;
- whey, brine, and their mixtures with kvass, which are historically documented [3], [6];
- fish in place of meat (historical fish okroshka) [6], [7];
- fasting variants without a protein filling, and egg-and-vegetable variants;
- beet and beet tops, at the boundary with cold beet soup and botvinya.

In contemporary Russian-language culinary practice, these variants are often called okroshka, while formally similar dishes from other traditions retain their own names; the prevalence and stability of these judgments have not been measured specifically. This raises the central research question:

> ***Which measurable physical and chemical attributes predict the structural–sensory typicality of okroshka, and can they predict category membership beyond recipe origin and cultural information?***

Methodologically, the study continues two theoretical manuscripts by the same author [30], [31]. Their models have likewise not undergone the empirical calibration described in them. Consequently, the comparison "no filter / flavor filter / physical filter" is a hypothesis of the research program, not the result of three completed investigations. For okroshka, a continuous similarity model, a fixed physical-threshold model, an exemplar model, and an information–context model of category judgment are compared. A decrease in observed similarity following a change in temperature or cutting will not, by itself, count as evidence of lost membership.

1.2. Etymology and historical context

Etymology. The dish's name refers not to an ingredient but to an operation: *okroshka* derives from *kroshit'*, meaning to crumble, chop, or cut finely. In Dahl's dictionary, the entry occurs in the word family "okrashivat' (obkrashivat'), o(b)kroshit'—to break off around," with the Tver example "we have already *okroshilis'*—finished chopping the cabbage"; the dish itself is defined as "a cold soup on kvass, made from chopped meat, onion, and other seasonings" [1]. The vocabulary and definition motivate treating coldness and cutting as candidate constitutive attributes, but do not in themselves establish the psychological structure of the contemporary category. Historical variation in the base shows that kvass was not the only documented liquid, but does not demonstrate the sensory interchangeability of bases.

Historical and typological neighbors: tyurya and botvinya. Okroshka belongs to a broader family of cold dishes with acidic liquid bases; the available sources do not establish direct descent of one dish from another. Tyurya is described as bread or rusks crumbled into water, kvass, or a milk-based liquid [9], while botvinya is described as a cold kvass soup with prepared greens and fish [8]. Because [8] and [9] are reference sources in the present corpus, they are used only to specify comparative stimuli and a typological question. They do not establish chronology, social prevalence, or a line of descent.

Early printed recipes. One of the earliest known printed descriptions of okroshka appears in Nikolai Osipov's *Starinnaya russkaya khozyaika, klyuchnitsa i stryapukha*. The first edition is usually dated to 1790, whereas the digitized copy available in the Russian National Electronic Library is the second edition of 1793 [2]. In a widely cited rendering, the recipe says to "chop various roasted meats with onion, cucumbers, and sour cream, add salt, and pour over cucumber brine, kvass, or sour shchi"; in this version, the quotation is reproduced from secondary publications, and its exact wording and page must be checked against the digitized original of the 1793 second edition in the National Electronic Library. The recipe is notable for two reasons: sour cream is present in this early attestation, and the base is specified through an explicit set of acceptable substitutions—"brine / kvass / sour shchi." Cold serving is documented for the category by the dictionary definition [1] and later recipes [5], [6]. The accessible rendering of Osipov's recipe contains no explicit serving-temperature instruction, so it cannot be cited as evidence of cold serving until the original has been checked. A few years later, in Vasily Levshin's *Slovar' povarennyi*, the dish is prepared "from leftovers of various roasted meats—quadrupeds, domestic and wild birds," with fresh and salted cucumbers, salted plums, and onion. Its liquid portion is not pure kvass, but a mixture of plum and cucumber brines, cider vinegar, and kvass; potatoes are absent or served separately, fried [3], [4]. In Molokhovets (1861), okroshka is an established recipe with chopped meat, cucumbers, herbs, and kvass [5]. The Brockhaus and Efron Encyclopedic Dictionary records a noteworthy detail: the okroshka mixture is to be "diluted with kvass **or sour shchi**," and fried fish is recommended for fasting okroshka without sour cream and eggs [6]. This early documented substitution of the base directly links the present work with the paired study

of shchi [30]. (The expression “sour shchi” is ambiguous in eighteenth- and nineteenth-century sources. When the context concerns pouring and use as a liquid base, it often denotes a separate acidic carbonated malt beverage related to kvass rather than cabbage soup; Dahl, for example, defines *sour shchi* as “a kind of effervescent kvass” [1, entry “Shchi”]. Thus this episode primarily demonstrates substitution among fermented beverage bases, not a “bridge” between okroshka and shchi soup.) Pokhlebkin states that a special **white (okroshka) kvass** was traditionally made for the dish from raw rye malt and flour: markedly more acidic and thicker than drinking kvass, without added sugar, and sometimes with mint or horseradish [7].

Soviet canonization and the kefir branch. Two shifts took place in the twentieth century. First, mass-market Soviet cookbooks established okroshka as a summer kvass dish [12]; the precise contents of the 1939 recipe must be cited to a specific page and are not used here as evidence that sausage, potatoes, or radish are obligatory. Second, contemporary practice includes a major kefir-based branch of the category. Its exact chronology requires a separate source and cannot be inferred from [12]; whether it constitutes an independent second prototypical center is treated below as a testable hypothesis. The post-Soviet period added a third, “compromise” base: mineral water with lemon juice or vinegar. The “kvass / kefir / mineral water” division is the central internal dispute in the contemporary category, and the present study moves it from opinion to measurement.

Folk historiography and its verification. Several accounts lacking reliable references circulate around the early history of okroshka. (1) The antiquity of kvass does not imply the antiquity of okroshka: the chronicle tradition mentions kvass substantially earlier than the fourteenth century, but the precise date and quotation must be taken from a critical edition of the *Primary Chronicle*, not the reference source [26]. (2) A brine-based proto-okroshka is chemically possible but not documented; Osipov’s recipe is merely the earliest attestation identified in the corpus used here, not demonstrably the first recipe ever [2]. (3) The story about Volga barge haulers has no documentary corroboration cited here and is not treated as a historical fact. These accounts may motivate experimental conditions but are excluded from the evidentiary chain concerning the dish’s origins.

Caveat on evidential value. The historical evidence in this section is directly relevant to the model, but its status must be defined precisely. Etymology and documentary history show repeated occurrences of finely chopped structure, cold serving, and variable liquid bases in the attestations examined, but establish neither the core of the modern category nor a hierarchy of attributes. Levshin’s use of brines mixed with kvass does not imply that modern okroshka is defined by brine. Contemporary perception is tested by experiment, not etymology (Section 7). The same principle applies in the paired works [30], [31]: historical and cultural review provides compatible context, not a basis for psychological conclusions.

1.3. Summary table of historical evidence

Consistent with the caveat on evidential value (Section 1.2), each historical fact is accompanied by what it permits one to suggest and what it does not establish:

Fact	What it permits one to suggest	What it does NOT establish
Etymology *okroshka* ← *kroshit’* (“to chop”); Dahl’s definition (cold kvass soup made from chopped meat) [1]	cutting and coldness were stable attributes of this lexicographical attestation	the structure of the modern category; the obligatory status of kvass
Tyurya and botvinya as historically attested neighboring forms of cold dishes [8], [9]	typological proximity within a broader family	direct genealogy of okroshka or sensory equivalence among the forms

Fact	What it permits one to suggest	What it does NOT establish
Osipov (1790 edition; available digitized copy of the 1793 second edition): one of the earliest known printed descriptions; sour cream included; base “cucumber brine, kvass, or sour shchi” (quoted from secondary publications; checking against the original is mandatory) [2]	early documented interchangeability of bases (three carriers in one recipe) and the presence of a fermented-milk component in this attestation	that this was absolutely the first recipe; sensory equivalence of the three bases; their prevalence in the eighteenth century
Levshin (late eighteenth century): liquid portion composed of brines, cider vinegar, and kvass [3], [4]	long-standing variability and composite nature of the acidic base	that modern okroshka is defined by brine or vinegar
Brockhaus and Efron: “dilute with kvass or sour shchi”; fasting okroshka with fish [6]	documented substitution of both base and filling by the nineteenth century	that sour shchi and kvass are sensorially equivalent bases
White (okroshka) kvass as a specialized ingredient [7]	the existence of a specialized base adapted to the dish (more acidic, less sweet)	its sensory superiority; the composition of such kvass in every region
A Soviet publication of 1939 documents the kvass branch [12]; the kefir branch is known from contemporary practice, but its chronology is not established in the present bibliography	continuity of the kvass recipe tradition; coexistence of several contemporary named bases as motivation for H4	the origin and date of the kefir branch; equal typicality of kvass- and kefir-based okroshka
The name “okroshka” was not found in the editions of *Domostroi* [30, Section 1.2] or Novgorod coaching-station books [31, Section 1.2] of the sixteenth–seventeenth centuries examined	only the absence of a named recipe in these two corpora	the date of the dish’s emergence or absence of cold chopped dishes in oral practice

1.4. Aim, objectives, and status of the study

Aim: To propose a falsifiable model predicting **a sample’s similarity to typical okroshka**, and a program to test whether physical attributes contribute additional explanatory power for **category membership** after accounting for cultural information and the described preparation history. The existence of a prototypical core, a physical threshold, and the superiority of a threshold model over continuous or information–context models are testable assumptions, not starting facts.

Objectives:

1. Identify and describe the functional parameters of the system (base, coldness, cutting, filling, acidity, herbs).
2. Construct a classification of okroshka variants along these parameters, including historical and borderline forms.
3. Analyze the liquid base as an independent variable using chemical-composition evidence.
4. Examine functional substitutes for the base, including historical precedents.
5. Formulate a preliminary index of structural–sensory similarity and comparison alternatives: continuous, physical-threshold, exemplar, and information–context models.
6. Design an experimental testing program with separate membership, typicality, and correctness outcomes; physicochemical and sensory measures; separate panels; and external validation on new recipes.

Status of the study. A theoretical and modeling investigation. The search conducted found no experimental studies specifically of okroshka; no original experiment was performed. The search was not a systematic review with a published strategy and therefore does not justify claims of exhaustive novelty or an absence of studies in other languages, databases, or disciplinary traditions. The manuscript distinguishes three levels of claim: **[Д]**—established by the cited source within its domain; **[П]**—transfer of evidence from adjacent fields to okroshka; **[Г]**—the author's own hypothesis.

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2. Materials and Methods

The study uses theoretical analysis and modeling and comprises four stages:

1. **Scientific literature analysis:** chemistry and microbiology of fermented beverages (kvass, kefir); temperature dependence of taste perception; perception of carbonation and trigeminal mechanisms of pungency; chemistry of volatiles in plant ingredients; and historical and culinary sources (dictionaries, cookbooks, regulatory documents). These are not treated as direct investigations of categorical perception of okroshka.
2. **Comparative classification:** systematization of known variants along identified parameters, including historical forms (Levshin, Molokhovets, sour shchi as a base) and borderline forms (botvinya, tyurya, cold beet soup, šaltibarščiai, tarator).
3. **Modeling:** construction of a preliminary Structural–Sensory Typicality Index for Okroshka (SSTIO, ИСТО) and explicit alternatives without a threshold, with a fixed physical threshold, with interactions, and with information–context predictors.
4. **Experimental-series design:** a reproducible methodology with objective measures: pH and titratable acidity, buffer capacity (using the paired study's protocol [30]), HPLC of organic acids, CO_2 content, and rheology. Category membership is measured by a neutral binary question; similarity to typical okroshka on a separate 0–10 scale; and correctness conditionally among samples judged to be okroshka. Training and validation are separated by independent batches, days, and recipe types.

Source-critical note. Scientific sources were selected through Google Scholar searches (September 2026) and labeled according to evidential strength ([Д]/[П]/[Г]; see Section 1.4). This was a targeted, not systematic, search: the manuscript does not provide a complete search string, database list, language restrictions, coverage dates, or selection flow diagram. Accordingly, the bibliography can support proposed mechanisms and design, but not a rigorous priority claim of novelty. The historical and culinary block [1]–[12] combines primary editions with online reference sources; the latter serve only to frame comparisons and must be replaced by academic or primary publications before journal submission. Regulatory GOST documents supply standards for industrial bases, not culinary prescriptions.

Unit of analysis and inclusion criteria. The historical unit is an individual dated recipe or dictionary attestation; prevalence in contemporary practice is not estimated from isolated publications. In the experimental program, the independent production unit is the batch, not an individual serving or taster rating. Repeated assessments of a batch are nested observations, not independent replications.

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3. Principal Parameters of Okroshka as a System

Okroshka is treated as a system with six functional axes and two modifiers. The axes enter the structural–sensory typicality model (Section 8), while carbonation and pungent seasoning modify perception. Their contribution to category membership is not assumed a priori and is tested separately.

3.1. Liquid base (axis O)

[Д] The liquid base carries acidity, sweetness, solids, and (in fermented bases) carbonation; historically, this axis marks the main divergence within the category. Three major types are distinguished:

1. **Kvass.** A product of joint fermentation by lactic acid bacteria and yeasts. *Lactobacillus casei*, *Leuconostoc mesenteroides*, and *Saccharomyces cerevisiae* were detected in the commercial kvass examined in [15], whose metabolite profile included lactate, acetate, and ethanol; the composition observed in one study is not extrapolated to all kvass. GOST 31494-2012 regulates kvass acidity (1.5–7.0 acidity units), solids (at least 3.5%), alcohol (not more than 1.2% by volume), and carbon dioxide (at least 0.30% for kvass packaged in bottles or aluminum cans) [13]. The historical specialized form is white (okroshka) kvass: more acidic and less sweet, without added sugar [7]. Among the bases considered, kvass combines acidity, extractive body, rye aroma, and possible carbonation; whether this combination is unique requires comparative analysis and is not accepted as an established fact.
2. **Fermented-milk bases** (kefir, ayran, cultured sour milk, buttermilk). Kefir results from symbiotic milk fermentation by lactic acid bacteria and yeasts assembled in kefir grains. Its standardized acidity is 85–130 °T; microbial gas formation is permitted [14]; its microbiota and metabolites (lactic acid, acetaldehyde, diacetyl, traces of ethanol and CO_2) are described in the review literature [16]. Unlike fat-free kvass, fermented-milk bases contribute a fat phase and protein.
3. **Acidified water and other bases** form a descriptive group in which the source of acidity must be distinguished: (a) mineral or ordinary water with lemon juice or vinegar, where acidity is primarily supplied by an added acidifier; and (b) whey and brines, including mixtures of brine and kvass, as in Levshin' s historical variant [3]. Whey from fermented-milk production and fermented-vegetable brine may contain fermentation products, including organic acids and volatiles. The absence of fermentation metabolites cannot therefore be ascribed to the whole group; nor can sugars, amino acids, and volatiles be ruled out even for water acidified with natural juice. The composition of each base must be tested instrumentally (Section 7, Experiment 2).

[П] Sensory extrapolation: by analogy with the borscht model [31], in which the acid source determines an acid profile but is not identical to perceived sourness, the base type (a coordinate of the code, Section 4.4) is intentionally separated from acidity intensity (axis К, Section 3.5).

3.2. Coldness (axis X)

[Д] Okroshka belongs to the cold-soup category. Historical sources do not prescribe one universal serving-temperature range; values such as 4–12 °C are used here solely as operational guides for future experiments. The temperature dependence of taste responses has been studied experimentally [18], [19], but the direction and magnitude of effects vary with modality, concentration, matrix, and temperature range. The TRPM5 study [18] identifies a mechanism of temperature sensitivity in part of taste transduction, but does not measure perception of okroshka. **[П]** Only the weaker hypothesis is therefore warranted for okroshka: changes in temperature may alter sweetness, sourness, bitterness, aroma, and overall typicality; the direction of each shift must be measured, not assumed. Coldness is treated as a candidate structural axis and a sensory regulator, not as an already demonstrated cause of a particular flavor balance.

[Г] Temperature is therefore proposed primarily as an axis of structural–sensory typicality and only secondarily as a candidate filter for category membership (Section 8). The prediction of reduced typicality and correctness under warming is distinguished from the stronger prediction of lost membership. The expression "regardless of composition and origin" is not assumed in advance; it requires replication across multiple bases and recipes.

3.3. Carbonation (modifier Г)

[Д] Fermented bases may contain dissolved CO_2 (the ≥ 0.30% requirement concerns kvass packaged in bottles or cans [13]; gas formation by microbiota is permitted in kefir [14]). Study [17] demonstrates contributions of carbonic anhydrase 4 and acid-sensitive taste cells to the response to CO_2; it neither reduces carbonation perception to mechanical stimulation by bubbles nor studies okroshka. **[П]** For okroshka, the question is whether measured carbonation changes perceived "refreshingness" and typicality when composition, temperature, and acidity are controlled. Simple degassing can also remove volatiles and alter the matrix. Thus a causal test requires sham-processed and recarbonated controls (hypothesis H5a). Carbonation remains a modifier because it varies within a single base type.

3.4. Pungent seasoning (modifier Тр)

[Д] Traditional pungent additions to okroshka include table mustard and grated horseradish [6], [7]. Their pungency comes from isothiocyanates acting, among other pathways, through TRPA1 in sensory neurons [20]. Radish also contains glucosinolates and may contribute pungency. **[П]** Extrapolated to okroshka, mustard–horseradish dressing and radish constitute a trigeminal component of the dish. Its relative strength compared with shchi and borscht has not been measured and remains a separate hypothesis. **[Г]** Prediction H5b is two-sided: a standardized mustard–horseradish note will alter typicality ratings; the direction is not considered established in advance.

3.5. Acidity (axis К)

[Г] An acidic component is assumed within the prototypical space being studied, but its universal necessity for everything called okroshka has not been established. Acidity may originate from fermentation (kvass: lactate and acetate [15]; kefir: predominantly lactate [16]) or be added (lemon juice, vinegar, brine [3]). **Chemical acidity** (pH and titratable acidity) is distinguished from **sensory sourness**, which depends on buffer capacity, temperature, sweetness, and the fat phase. Buffer capacity is measured by titrating with a standardized acid or alkali over a prespecified pH interval. Local buffer capacity $\beta = |\Delta n|/(V \cdot |\Delta pH|)$ has units $mol \cdot L^{-1} \cdot pH^{-1}$ for Δn in moles and V in liters. Titration direction, temperature, stirring rate, and pH interval are fixed before the experiment. Dilution, masking, and chemical neutralization must be analyzed separately; mustard–horseradish and salty notes may alter the overall sensory rating but do not chemically neutralize acid.

3.6. Dicing (axis Н)

[Д] Cutting is the only axis directly motivated by the dish' s name (*kroshit'* , "to chop" [1]). Sources confirm a chopped structure but establish no universal historical cut size; the 3–7 mm range is used as an experimental anchor. Source [21] describes the chemistry of *Allium* volatiles, and [22] the effect of shading on cucumber aroma; neither establishes an effect of cube size in okroshka. **[Г]** H3 therefore primarily tests a geometric mechanism (particle count, surface area, and distribution of ingredients within a spoonful). Any aromatic contribution is recorded as a separate explanation and requires direct measurement of volatile profiles after standardized cutting. A monotonic change in prototype similarity with increasing cut size is to be tested, not deduced from fresh-cut chemistry. Dicing is a candidate threshold for physical typicality; its necessity for membership is not assumed.

3.7. Solid filling (axis П)

[Д] The protein- and starch-rich solid fraction has historically varied: mixed boiled or roasted meats [3], ham and sausage (Soviet norm [12]), lightly salted or fried fish [6], eggs, and boiled potatoes (a later ingredient, absent in Levshin or served separately, fried [3], [4]). The filling provides satiety and may contribute umami. **Umami** is a basic taste associated primarily with glutamate and certain nucleotides [23]. Its relative intensity in okroshka has not been measured here; therefore the weight of axis П is not derived from

an assumption of "weak umami," but has only an a priori pilot status and must be calibrated along with the other weights.

3.8. Herbs and aroma (axis З)

[Д] Fresh greens form a typical aromatic layer, but have not been shown to be universally obligatory: scallion, dill, fresh cucumber, and radish. Historical recipes include tarragon and aromatic herbs [6], while white kvass was infused with mint and horseradish [7]. The layer's chemistry involves fresh-cut volatiles (Section 3.6) and mild radish pungency (Section 3.4). **[П]** Axis З is the principal carrier of "freshness" and interacts with axis Х: coldness and green aromatics reinforce each other in the perception of "refreshingness."

3.9. Accompaniments (layer М—external modifier)

As in the paired studies [30], [31], accompaniments are treated as an **external cultural modifier** rather than a structural axis: sour cream (or mayonnaise, a later substitute) added to the bowl; mustard and horseradish served separately; ice; and hot boiled potatoes alongside the cold soup—a ritual brought to canonical form in the Lithuanian tradition of šaltibarščiai [11]. Sour cream, as with shchi, performs a dual role: serving element and final regulator of perceived sourness and thickness (masking in the classification of [30]). The functional logic of accompaniments is shared by the three dishes: fat-rich and starchy additions soften the acidic axis, while pungent additions allow diners to adjust trigeminal intensity individually.

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4. Classification of Okroshka Variants

4.1. Existing approaches

[Д] Available classifications of okroshka fall into two types. **Dictionary definitions** capture a prototype ("kvass + chopped meat + herbs, served cold" [1]) without describing internal diversity. **Enumerative lists** in cookbooks and recipe collections name variants ("meat okroshka," "kefir okroshka," "fasting okroshka," "fish okroshka" [5], [12]) without specifying a feature system that generates this diversity. Both approaches encounter the same impasse noted for borscht in the paired study [31]: listing variants does not explain why members of the culinary tradition assign them to one category or where its boundary lies.

4.2. Functional matrix: component → functions

[Г] (An expert hypothesis to be recalculated against empirical data, following the conventions of the paired studies [31].) Each component fulfills one or more functions along the axes:

Component	О (base)	Х (coldness)	Н (cutting)	П (filling)	К (acidity)	З (herbs)	Modifiers
Kvass	✔				✔ (lactate, acetate)		Г (CO_2), sweetness
Kefir / ayran / cultured sour milk	✔			(protein, fat)	✔ (lactate)		Г (weak), fat phase
Mineral water + lemon juice / vinegar	✔				✔ (added)		Г (if carbonated)
Whey, brine	✔				✔		salt
Fresh cucumber			✔			✔	fresh-cut aroma
Boiled potato			✔	✔ (starch)			

Component	О (base)	Х (coldness)	Н (cutting)	П (filling)	К (acidity)	З (herbs)	Modifiers
Meat / sausage / ham			✔	✔			umami background
Fish (lightly salted, fried)			✔	✔			umami background, salt
Egg			✔	✔			umami background
Radish			✔			✔	Тр (mild pungency)
Scallion, dill, aromatic herbs			✔			✔	aroma
Mustard, horseradish							Тр (TRPA1)
Sour cream					(masking)		fat phase (layer М)
Ice		✔					dilution

The matrix illustrates carriers' multifunctionality (kvass spans О, К, and Г; radish spans Н, З, and Тр). This is the same source of collinearity among axes identified in the paired studies (beet in borscht, sauerkraut in shchi [30], [31]) and addressed in the statistical plan (Section 7).

4.3. Main classification

[Г] The axes in Section 3 permit the following types:

1. **Classic meat okroshka on kvass:** a proposed category prototype with white or bread kvass, meat filling, cucumber, herbs, and sour cream [1], [5], [7].
2. **Fasting / fish okroshka on kvass (historical):** kvass with fish (lightly salted or fried), or vegetables without meat or eggs [6], [7].
3. **Kefir (fermented-milk) okroshka:** a candidate second category center, with kefir, ayran, or cultured sour milk; its Soviet and post-Soviet chronology and prevalence have not been established in the present corpus.
4. **Okroshka on acidified water** ("on mineral water"): a later compromise form with added acidity.
5. **Okroshka on whey / brine:** marginal contemporary forms with historical precedent (Levshin's brine-and-kvass mixtures [3]).
6. **Mixed-base okroshka:** kvass plus sour cream incorporated into the base rather than added when serving, or kefir plus mineral water (dilution), occupying intermediate positions between types 1 and 3.
7. **Beet okroshka (okroshka with beet):** a borderline form retaining chopped structure but including beet or beet tops; the paired study describes it as an "assembled cold soup of the okroshka type" [31]. Membership is not assigned by the model but tested by a panel (Section 8.1).
8. **Historically named neighboring forms:** tyurya (bread crumbs as a different carrier of solids) and botvinya (cooked greens, a different processing method) [8], [9]; **convergent forms:** tarator [10], šaltibarščiai [11], gazpacho, Azerbaijani ovdukh and dovga [27; 28], and Belarusian kholodnik [29]—structural neighbors in other traditions (Section 8.1).

4.4. Type code

[Г] A five-coordinate type code is proposed:

Ок = (О, Х, Н, П, К)

where:

- **О (liquid base):** О1—bread kvass; О2—white (okroshka) kvass; О3—kefir; О4—cultured sour milk / ayran / buttermilk; О5—acidified water; О6—whey / brine; О7—mixed base;
- **Х (serving temperature):** Х1—4–12 °C (cold, with or without ice); Х2—room temperature; Х3—warm/hot (outside the prototypical serving regime; the code does not assign category membership);
- **Н (solid-phase structure):** Н1—finely chopped (3–7 mm); Н2—medium (8–12 mm); Н3—coarse (>12 mm); Н4—grated, with discernible particles; Н5—puréed, without a chopped structure;
- **П (solid filling):** П1—boiled/roasted meat; П2—sausage/ham; П3—fish; П4—egg and vegetables; П5—purely vegetable/fasting without egg; П6—mixed; П0—no solid filling;
- **К (origin of acidity):** К1—kvass fermentation; К2—fermented milk; К3—added (citric acid, lemon juice); К4—vinegar; К5—brine; К6—mixed.

For classic meat okroshka on kvass, the code reads "Ок(О1; Х1; Н1; П1; К1)"; for kefir okroshka with sausage, "Ок(О3; Х1; Н1; П2; К2)." Coordinate К encodes the **origin** of acidity; axis К in the index represents its **intensity** (Section 8), mirroring the borscht study (acid source in type code Б, intensity in axis К [31]). Serving ritual and accompaniments are excluded from the code as an external cultural modifier (layer М, Section 3.9).

4.5. Similarity metric for variants

[Г] By analogy with [31], a formal measure of differences between variants is introduced. **The baseline is a Hamming measure for simple coordinates generalized to Jaccard distance for composites:** the unnormalized sum d_H ranges from 0 to 5 when all coordinates are present. Composite values use the Jaccard distance between sets of values. The normalized distance $d_H^* = \Sigma d_j/m$ is permitted only for pairs with the same prespecified set of m coordinates. When sets of observed coordinates differ, distances are considered noncomparable and are not pooled into rankings; multiple imputation may be used only as sensitivity analysis.

Hamming distance is deliberately coarse: it does not distinguish adjacent from distant values within a coordinate. A **typed dissimilarity measure** is therefore specified, $d_f = \Sigma_j w_j \cdot d_j(x_j, y_j)/\Sigma_j w_j$. The primary version includes О, Х, Н, and П; coordinate К is excluded because in many recipes acidity origin is determined by base type and would double-penalize one substitution. Sensitivity analysis may replace О with К or include both, with combined weight equal to О's original weight. All d_j are scaled to 0–1: prespecified distances between ordinal levels for Х and Н; 0/1 distances or Jaccard distance for composite nominal О and П. Until a full table of d_j is specified, the expression is a specification of a future measure, not a completed metric. **Criterion for accepting complexity:** the typed metric replaces the baseline only if it better predicts similarity to typical okroshka on held-out recipes; binary membership is tested by a separate model.

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5. Liquid Base as an Independent Variable

[Д → П] Mirroring the paired study's section "Types of Beet as an Independent Variable" [31], the liquid base is varied while the chopped mixture is held constant. The available carriers differ in measurable chemical parameters:

Base	Acidity type	Dominant acids	CO_2	Solids / fat	Regulatory framework
Bread kvass	fermentative	lactic, acetic [15]	≥0.30% only for bottled/canned product [13]	≥3.5% solids; fat not regulated by this standard [13]	GOST 31494-2012
White (okroshka) kvass	fermentative	lactic, acetic; no added sugar [7]	present	greater extractive body than drinking kvass [7]	historical process [7]
Kefir	fermented milk	lactic [16]	gas formation permitted [14]	fat: fat-free <0.5%, regulated values up to 8.9%; protein ≥3.0% [14]	GOST 31454-2012
Cultured sour milk / ayran / buttermilk	fermented milk	lactic	absent to weak	variable	—
Acidified water	added	citric / acetic	if carbonated	low; depends on mineralization and proportion of juice	—
Dairy whey	depends on processing (acid whey or sweet rennet whey)	predominantly lactic in acid whey	absent to weak	low	—
Brine (cucumber, cabbage)	fermentation + salt	lactic, acetic	absent	low solids, high mineralization	historical precedent [3]

[II] Each row is an experimental condition for Experiments 1 and 2 (Section 7). Model predictions are: (1) replacing the base shifts the flavor profile along O, K, and modifier Γ; retention of category membership is a separate hypothesis H7 and cannot be inferred from preserving coldness, cutting, and the acidic function; (2) fermented bases can be differentiated from bases with added acid by accompanying metabolites (sugars, amino acids, volatiles), even when pH and titratable acidity are matched—the level Б/В/Г contrasts in Experiment 2; (3) a kefir base changes not only acidity but also the fat phase, which may contribute to preference segmentation (H4), but does not in itself explain the category boundary.

Instrumental and sensory comparison of bases. These levels are not combined before data are obtained. The instrumental vector is A_chem = (c_1, ⋯, c_q, pH, TA, β, CO_2, Brix, η), where $c_1 \cdots$c_q are molar fractions of a prespecified set of organic acids; TA is titratable acidity to a common endpoint pH; β is local buffer capacity; Brix represents soluble solids; and η is viscosity at a specified temperature and shear rate. After standardization on the training series, d_chem is defined as Euclidean distance with initially equal weights for the blocks "acids," "acid–buffer measures," CO_2, solids, and viscosity. Weights and coordinates are fixed before validation.

The sensory vector A_sens = (I, D, P, R) is assessed by a separate trained panel: I is peak sourness intensity; D is duration of sensation; P is time to peak; R consists of prespecified descriptors of sourness character. I, D, and P are derived from a time–intensity protocol [32], while R is obtained through quantitative descriptive analysis with published anchors [32], [33]. The distance d_sens is computed only after panel repeatability is evaluated and coordinates are standardized. No prior assumption is made that kefir and ayran are close: this is tested on independent batches, since salt, fat content, dilution, and fermentation

technology may alter both distances. Experiment 1 supplies A_chem and d_chem; A_sens and d_sens are outcomes of the sensory component of Experiment 3.

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6. Functional Substitutes for the Base

[Д → П] Mirroring the paired study's treatment of beet substitutes [31], if kvass is not the only carrier of the acidic function, the category permits a ladder of substitutions, each with historical or practical precedent:

1. **Kvass → kefir / cultured sour milk / ayran:** the major contemporary transition (Soviet/post-Soviet branch [12]); it preserves fermentative origin of acidity, alters the chemical profile, and adds a fat phase.
2. **Kvass → acidified water:** substitutes the carrier while retaining acidity but losing accompanying metabolites and extractive body; the sensory distance from the prototype is proposed to be maximal among "permitted" substitutions (tested in Experiment 3).
3. **Kvass → whey:** a marginal contemporary substitution, chemically intermediate between fermented-milk and water-based groups.
4. **Kvass → sour shchi:** a historically documented substitution in Brockhaus and Efron [6]. Here "sour shchi" should primarily be interpreted as an acidic, carbonated malt beverage related to kvass (compare Dahl's "a kind of effervescent kvass"[1]); this example supports substitution among fermented beverage bases but does not demonstrate a connection between okroshka and cabbage soup.
5. **Pure kvass → composite base** (brines + vinegar + kvass): a historical norm in Levshin [3], in which the base was already a configurable mixture rather than a single product.

[Г] The substitution ladder proposes an empirically testable order: expected distance from the prototype increases along "white kvass → bread kvass → kefir → cultured sour milk/ayran → whey → acidified water" (Levshin's composite bases occupy intermediate positions). This ordering follows directly from the model in Section 8 and is tested using graded similarity in Experiment 3. **Caveat: "object A ≠ object B"** (following [31]): the category's historical breadth does not rule out narrowing in its contemporary form. The ladder describes the system's potential, not equal typicality of every step for present-day members of the tradition.

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7. Experimental Testing Program

Eight key hypotheses

The model yields eight falsifiable predictions (numbered in parallel with the paired borscht study [31]; links to the paired hypotheses are stated explicitly):

- **H1.** Liquid-base type is a candidate strong group-level predictor of structural–sensory typicality. Its additional predictive value for category membership is evaluated after incorporating supplied information about preparation history, the name, and cultural covariates. Strength is assessed not by magnitudes of incomparable regression coefficients, but by deterioration in a prespecified validation metric when the entire base-feature block is excluded on held-out recipes. Categorical base type, measured matrix characteristics, and acidity are analyzed separately; predictive importance does not entail causal interpretation.
- **H2a.** Temperature changes similarity to typical okroshka and conditional ratings of correct serving. **H2b.** Membership judgments exhibit an interaction between temperature and supplied information about common origin: information increases membership probability more for a warm than for a cold sample. The 8 °C versus 35–40 °C contrast is the primary contextual-sensitivity test; 60 °C is an extreme supplementary condition only, since heating changes volatility, texture, CO_2, and the state of the herbs. Persistence of the temperature gap with information would support a physically autonomous

judgment model; attenuation would support an information–context model. Neither result alone establishes an ontological role for actual recipe genealogy.

- **H3.** Cut size affects typicality and correctness in a graded fashion: with composition fixed, a 5 / 10 / 20 mm series predicts monotonically declining ratings. A change in category membership is a separate, stronger prediction and does not automatically follow from calling the sample "salad covered with liquid."
- **H4.** The category may have multiple prototype centers, primarily kvass- and kefir-based. This requires distinguishing clusters of stimuli from clusters of respondents' representations: dividing samples by known base does not itself demonstrate two prototypes. The principal criterion is reproducible improvement of a multiple-center model on held-out recipes and in an independent cultural subsample compared with one-center, exemplar, and simple categorical models. The "base type × habitual base" interaction tests respondent segmentation but does not replace this criterion.
- **H5.** Two independent sensory modifications are consequential: **H5a**—CO_2 content changes typicality and "refreshingness" ratings among initial, sham-processed, degassed, and recarbonated samples from one batch; **H5b**—adding a standardized mustard–horseradish note changes typicality at a fixed base. Both hypotheses are two-sided; confirming one does not confirm the other.
- **H6.** Cross-category discrimination: a panel distinguishes prespecified standardized okroshka samples from structural neighbors. The primary metric is the proportion of correct free names against a prespecified key; the secondary metric is binary-membership entropy. Higher uncertainty for borderline samples is confirmed only if mean entropy exceeds that of prototypical and negative-control samples by a prespecified minimum determined in the pilot.
- **H7.** Transferability of category membership under base substitution: with the chopped mixture fixed, replacing kvass with kefir and then a prespecified series of bases may preserve binary membership. "Functional substitutability" means retention of the category response, not chemical or sensory equivalence. Direction and magnitude of shifts in prototype similarity are estimated separately and not presupposed; a monotonic order along the ladder is a separate exploratory prediction.
- **H8.** Nonadditive architecture: K × H and K × Tp interactions improve prediction on held-out data relative to an additive model. Only a positive interaction in a prespecified direction is interpreted as compensation; statistical significance of an arbitrary interaction does not itself establish compensation.

Effect sizes and estimands. For binary membership, the primary quantities are marginal standardized differences in probability averaged over the empirical distribution of prespecified covariates. For graded outcomes, marginal differences in expected scores and probabilities of exceeding each scale threshold are reported. Ninety-five-percent intervals are calculated from the registered mixed model using parametric bootstrap over participants and batches. Values of 0.25 for a probability difference, ±0.10 for the practical-equivalence region, and 1.5 points on the 0–10 scale are not treated as known minimally important effects: here they are only inputs for simulation-based power analysis. Before the confirmatory series, they must be fixed using a blinded pilot and expert procedure; conclusions will additionally undergo sensitivity analysis to these limits.

Experiment 0. Pilot survey on obligatory attributes

[Γ] Before the laboratory series, a survey will recruit respondents culturally familiar with the dish (at least 30 participants for questionnaire debugging only; the main panel size is power-based). Initial panel criteria are specified before responses: age at least 18; Russian as one language used at home before age 16; at least ten years' residence in prespecified recruitment regions; and having eaten or prepared okroshka at least twice in the preceding 24 months. Geography, age strata, education, habitual base, and cooking experience are quota-sampled and published. Respondents below the familiarity threshold are not excluded from the entire study, but form a predefined external comparison group. These criteria describe a sample and grant it no normative authority over the category.

Participants report which attributes they regard as obligatory (kvass, cold serving, fine cutting, meat filling, herbs, acidity, carbonation). The survey measures declared norms, not the actual category boundary. The preliminary expectation that coldness and cutting will be named more often than kvass is a hypothesis. The trained sensory panel and cultural panel are recruited independently and cannot substitute for each other.

Experiment 1. Chemistry of liquid bases

[Г] The aim is to quantify the independent variable in Section 5. Each base type has at least three independent pilot batches; the main-series batch count follows from between-batch variance. Measurements include initial pH; full titration curves with standardized acid and alkali; titratable acidity to one common, prespecified endpoint pH for cross-matrix comparisons; local β; HPLC of organic acids; CO_2; sugars; solids; density; and viscosity. Acidity values to different endpoints (e.g., pH 6.0 and 8.1) are reported as technical indicators but not directly compared across matrices. Analytical methods specify technical replicates, blanks, calibration ranges, detection limits, and treatment of results below the limit of quantification. Outputs are the A_chem table and pairwise d_chem values with uncertainty. Their association with sensory sourness is assessed only once independent A_sens measures become available from Experiment 3.

Experiment 2. Four-level design of aggregate matrix contrasts

[Г] A separate family of comparable samples is constructed for each real base. All levels use the same standardized chopped mixture, liquid-to-solid ratio, temperature of 8 ± 1 °C, and elapsed time after mixing:

- **Level Б—single acid:** standardized aqueous matrix containing the corresponding base's dominant acid; pH is matched to the real base, while titratable acidity is recorded as a separate outcome;
- **Level В—acid profile:** a mixture of pure acids reproducing the real base's HPLC-measured molar acid profile and pH;
- **Level Г—reconstructed matrix:** Level B supplemented with measured salt, sugars, solids, viscosity, and CO_2 to the real base's values, but without its volatiles, unidentified metabolites, or guaranteed replication of colloidal microstructure;
- **Level А—real base:** kvass, kefir, or acidified water without artificial reconstruction.

Contrasts Б→В, В→Г, and Г→А are **aggregate contrasts between nested formulations**, not a clean causal decomposition of individual mechanisms. Б→В compares a dominant acid with a measured acid profile; В→Г compares that profile with a reconstructed package of nonacid characteristics; Г→А compares the reconstruction with the real base, including all unidentified differences and reconstruction error. Exact recipes and tolerances for matching pH, acid concentrations, sugars, salt, solids, CO_2, and viscosity are published for every matrix. For kefir, particle/aggregate size and the rheological curve are additionally measured: matching pH, solids, and one viscosity point is not considered replication of the protein–fat colloidal structure. Causal attribution to an individual component requires an additional orthogonal add/remove subseries. pH and titratable acidity cannot be declared independently and simultaneously matched when a particular acid system makes this impossible: one is targeted and the other recorded and modeled. Subseries H5a divides one kvass batch into initial, sham-processed, degassed, and recarbonated-to-initial-CO_2 samples, with pH, CO_2, and volatile profiles remeasured afterward. Without sham and recarbonated controls, an effect cannot be attributed specifically to CO_2.

Experiment 3. Separate measurement of membership, typicality, and correctness

[Г] A panel of 8–12 trained tasters assesses sensory profiles of a dish series: prototypes on three bases; borderline samples (beet okroshka); historically neighboring forms (botvinya, tyurya); structural neighbors (tarator, šaltibarščiai, gazpacho); cross-category negative controls (shchi and borscht at 65 ± 2 °C and cooled to 8 ± 1 °C); and mirror conditions (warm prototype, coarse cutting, degassed kvass). Comparative dishes'

compositions are standardized before data collection. Weak reference sources guide stimulus construction only, not claims about genealogy.

A separate cultural panel responds in a fixed order: (1) freely name the dish; (2) answer the neutral binary question, "Do you classify this sample as belonging to the category 'okroshka'?"; (3) rate on a scale applicable to every sample, "How similar is this sample to typical okroshka?" from 0 ("not at all similar") to 10 ("maximally similar"); and (4), only when membership is answered "yes," rate "How correctly has this okroshka been prepared or served?" from 0 to 10. Correctness uses a two-part model: recognition as a member and, conditional on recognition, distribution of correctness. No zero correctness score is imputed to "no" membership responses. Confidence in the binary decision is recorded separately (0–3).

For H4, the stimulus population is defined before analysis as recipes satisfying the minimal structural formula "cold liquid base + discrete chopped mixture," then stratified by stated base without selecting for expected typicality. The calibration series includes at least eight independently formulated recipes for each prespecified branch and within-branch compositional variation; at least four new recipes per branch are reserved for external validation. These minima do not replace power analysis. Mixture-model component count is selected using held-out performance and bootstrap stability of centers; component correspondence with predefined base groups is not itself proof of psychological prototypes. If power is inadequate, H4 remains exploratory.

Between-person disagreement is measured by the entropy of binary decisions at response proportion p: $H = -p \cdot \log_2 p - (1-p) \cdot \log_2(1-p)$, with $0 \cdot \log_2 0 = 0$. This measures group disagreement, not individual uncertainty. **Calibration without circularity:** the sample is split by batches and days; SSTIO parameters are estimated against similarity in training data only and tested on held-out data. A separate category-membership model includes physical attributes, supplied information, described preparation history, and cultural covariates. The sensory panel is not treated as the "gold standard" for the cultural category. **Contrast subseries:** a structurally similar sample with a distinct established name and a canonically named recipe with deliberately reduced SSTIO are included. Divergence of similarity and binary membership is substantive, not measurement error. **Generalization test:** cross-validation holds out an entire recipe type.

Additional requirements for the categorical panel. Criteria and stratification are specified in Experiment 0. For the main test, information is a between-subjects factor: respondents are randomized to no origin information or to a neutral message that two servings came from one batch and differ only by a registered intervention. No respondent moves from the informed state back to a blind state. Temperature order is randomized within each group. A separate repeat-presentation control without new information measures familiarity effects but is excluded from the primary contrast. Direct labeling as "okroshka" is investigated separately because the name can induce a response. Main-panel size is established by simulation-based power analysis incorporating batch, participant, and interaction.

Experiment 4. Contextual sensitivity of category judgment

[Γ] The aim is to distinguish physically autonomous and information–context models with minimal intervention. Independent canonical batches are divided into cold (8 ± 1 °C) and warm (35–40 °C) portions, holding composition, phase ratio, vessel, and time since mixing fixed. Participants are randomly assigned to two information groups before tasting: group U receives no information about portions' origins; group I is neutrally told that both portions came from one batch and differ only by the temperature intervention. Within each group, each participant assesses both temperatures in random order. Binary membership is primary; similarity to typical okroshka and conditional correctness are secondary.

The physically autonomous model predicts a similar membership temperature gap in U and I. The information–context model predicts that the common-origin message will reduce the gap, chiefly by increasing membership for the warm sample, while the prototype-similarity gap persists. Since actual preparation

history is identical across conditions and only knowledge of it changes, such a result indicates contextual sensitivity of judgment, not that recipe genealogy constitutes dish identity.

The primary logistic mixed model is `membership ~ temperature * information + period + order + (1 + temperature | participant) + (1 | batch)`. If the random slope is not identifiable, simplification follows a prespecified rule. The primary estimand is the marginal probability-scale interaction δ = [P(member|warm,I) − P(member|cold,I)] − [P(member|warm,U) − P(member|cold,U)], standardized over registered covariates. The four component probabilities and differences Δ_U and Δ_I are also reported. Prototype similarity uses an ordinal mixed model; correctness uses a two-part model. A confidence interval for δ wholly inside a prejustified practical-equivalence region around zero, alongside a reproducible temperature effect, supports the physically autonomous model. A positive δ outside that region with an enduring similarity temperature gap supports the information–context model. An interval crossing both decision regions leaves the models unresolved. Numerical boundaries are established before the main series through a blinded pilot and sensitivity analysis, not asserted as properties of the category.

An extended psychometric series at 5, 10, 15, 20, 25, 35, 45, and 60 °C evaluates the shape of temperature dependence; 60 °C is treated as a compound intervention. A separate subseries varies cut size at 5, 8, 12, and 20 mm at 8 °C. Actual temperature at first sip, holding time, CO_2 loss, viscosity, and herb condition are recorded. Testing **actual** recipe history requires a different future design: independently prepared, sensory-matched samples crossing true and communicated histories; without an ethically permissible information manipulation, this mechanism is not identifiable. As no original data have been collected, no possible outcome is presented as realized.

General protocol and statistical plan

The pilot calls for 3–5 independent batches of each variant; this range is solely for debugging and variance estimation, while main-series batch and participant counts are determined by simulation-based power analysis accounting for clustering. A batch is a separate preparation of the base and mixture; portions and repeated ratings are nested within it. Samples are coded, serving order counterbalanced, and temperature and time after mixing recorded. Samples per session are limited using a balanced incomplete-block design. Inter-sample intervals and neutral palate cleansing are standardized; portion volume, vessel, and lighting are fixed. Binary membership uses a logistic mixed model; similarity on the 0–10 scale uses a cumulative ordinal mixed model if the proportional-odds assumption is acceptable, otherwise a partial proportional-odds model; correctness uses a two-part model. Calibration and validation use independent batches; exclusion criteria, missingness, outliers, and recruitment stopping rules are specified before unblinding.

Hierarchy of confirmatory tests. The sole primary outcome of Experiment 4 is binary membership; its sole primary contrast is the marginal interaction δ of temperatures 8 and 35–40 °C with information U/I. A second-tier confirmatory family comprises the temperature effect on prototype similarity (H2a), portability across prespecified bases (H7), and predictive value of the base-feature block (H1), with Holm correction. H3, H5a, and H5b constitute a separate mechanistic family with Holm correction. H4, H6, H8, supplementary temperatures, regional interactions, and mixture models are exploratory and subject to FDR control within explicitly listed families. Different outcomes are not pooled into an implicit set of "positive" findings.

Comparing similarity models. Let y_i denote an ordinal similarity rating of 0–10, x_ij the six prescaled axes, and b_participant and b_batch random effects. T1 is the cumulative logit model `logit P(y_i ≤ k) = θ_k − [Σ_j β_j x_ij + b_participant + b_batch]`. For T2, a physical-threshold violation indicator `F_i = 1[X_i < 0.5 or H_i < 0.5]` is fixed in advance and `γF_i` added to T1's linear predictor; threshold 0.5 is not tuned on validation data. If the threshold is explored, its selection is fully nested inside an inner nested-cross-validation loop while the external series remains untouched. T3 adds prespecified `K×H` and `K×Tp` interactions to T1; since Tp is not part of SSTIO,

it enters as a separately measured covariate. Models are compared by external mean negative log-likelihood and calibration of ordinal probabilities. Neither ROC nor post hoc binarization of similarity is used.

Comparing membership models. M0 includes only prespecified cultural covariates; M1 physical and chemical axes; M2 supplied information and described preparation history; M3 their combined set; M4 additionally `temperature × information`. Comparison uses held-out log loss, Brier score, probability calibration, and intervals for marginal contrasts. A similarity model is not renamed a membership model after the fact, even if outcomes correlate strongly.

Ethics and safety. Before research involving human participants begins, approval through the applicable ethics process, informed consent, a right to withdraw, and a data-protection plan are required. Allergens (milk, egg, mustard, fish), alcohol and fermentation products, individual dietary restrictions, food safety of cold mixtures, and the upper safe serving temperature are considered. These are substantive conditions determining permissible panel and sample composition.

Confounder matrix

Confounder	Mechanism	Control
Kvass sweetness	shifts perceived sourness and typicality independently of acids	measure sugars in Experiment 1; sugar-free levels Б/В
Carbonation	affects "refreshingness" independently of acidity	degassed control (H5); include CO_2
Kefir fat content	fat masks acidity and changes texture	fat-content gradation in Experiment 1; level Г
Freshness of cut ingredients	fresh-cut aroma diminishes over time	cut just before serving; fixed holding time
Sample temperature at tasting	directly alters perception (H2)	temperature control when serving; model covariate
Taster's habitual base	systematic rating bias (H4)	panel questionnaire, random effect (1 | taster), interaction factor
Base color (dark kvass / white kefir)	visual channel influences identification	control subseries using opaque vessels

Pilot and main series

The program separates a pilot (one prototype base, three batches, protocol development, variance estimation for power analysis) from a main series (full factorial design of Experiments 2–3). Advancement criteria are registered in advance: pH/titratable-acidity reproducibility within 5%; panel repeatability on duplicate samples reaching a prespecified weighted κ threshold for categorical responses and ICC for graded ratings.

Interpretation of negative results

Negative finding	What it refutes	What does NOT follow
H2a unsupported (warming fails to reduce typicality/correctness)	temperature as a strong typicality axis in the tested range	that temperature has no effect on individual sensory modalities
H2b unsupported (δ practically equivalent to zero)	a substantive contextual modification of the temperature effect by the tested message	that actual genealogy has no effect in other designs, or that coldness does not determine similarity or serving norms
H4 unsupported (mixtures fail to outperform a single-component model on new recipes)	stable multiple centers in the selected stimulus population	that kvass- and kefir-based variants are sensorially indistinguishable (see d_sens)

Negative finding	What it refutes	What does NOT follow
H5a unsupported	substantive CO_2 effect on similarity/ "refreshingness" in the tested range	that carbonation itself cannot be perceived
H5b unsupported	substantive effect of a standardized mustard–horseradish note	that other doses or seasoning compositions have no effect
H7 unsupported (base substitution disrupts identification)	functional substitutability of the carrier	that historical substitutions did not exist (documented in [3], [6])
d_chem(kvass, kefir) ≈ within-repeat-batch level	distinguishability of measured instrumental base profiles	that sensory profiles coincide (assessed separately as d_sens)

Traceability matrix

Hypothesis	Variable	Experiment	Falsifier
H1	base type and properties O	3 (held-out validation)	removing the base block does not meaningfully worsen typicality prediction
H2a / H2b	temperature; common-origin information	4 (8 vs 35–40 °C; information between groups)	H2a: no meaningful similarity change; H2b: marginal interaction δ falls in the equivalence region around zero
H3	cut size	4 (psychometric series)	no prespecified monotonic decrease in typicality and correctness
H4	sensory space × base type × habit	3 (multilevel model; mixture analysis supplementary)	multiple centers do not improve validation performance on new recipes
H5a / H5b	CO_2; mustard/horseradish	2 (factorial degassing); 3 (factorial seasoning)	no corresponding change after other parameters are controlled
H6	dish category	3 (negative controls)	neighboring categories cannot be distinguished from the core
H7	substitution-ladder step	3	binary membership is not retained; monotonic typicality is tested as a separate prediction
H8	K × H, and separately K × Tp	3–4	interaction model fails to outperform additive model on validation data

8. Theoretical Model: The Structural–Sensory Typicality Index for Okroshka

[Г] The working hypothesis is that a combination of attributes predicts structural–sensory typicality better than any single ingredient. One of the competing formalizations is specified below: the preliminary **Structural–Sensory Typicality Index for Okroshka (SSTIO; ИСТО in Russian)**. It is not a measured natural quantity and, fundamentally, is not used by itself to decide whether a dish belongs to the category:

SSTIO = w_1·О + w_2·Х + w_3·Н + w_4·П + w_5·К + w_6·З

where:

- **О (matrix similarity of the liquid base)** is an illustrative summary of measured nonacid properties; acidity is excluded and measured by separate axis К. For sample i, following standardization on the training series, `O_i = exp[−0.5·min_c D²_M(z_i, μ_c, Σ_c)]`, where z comprises solids, protein, fat, parameters of the rheological curve, and prespecified fermentation markers, while c indexes only the preselected reference kvass and fermented-milk matrices. Centers μ_c and covariance matrices Σ_c are estimated without the validation recipes. О measures similarity to one of the reference matrices, not quality;
- **Х (coldness):** degree to which cold serving is realized;
- **Н (cutting):** degree to which a finely chopped structure is realized;
- **П (solid filling):** presence and completeness of the protein- and starch-rich solids (meat, fish, egg, potato);
- **К (acidity):** intensity of the acidic component irrespective of origin (a sensory scale calibrated against chemical measurements; Section 3.5);
- **З (herbs):** completeness of the fresh aromatic layer (cucumber, onion, dill, radish, aromatic herbs);
- **w_1⋯w_6:** coefficients, with a priori starting values w = (0.25, 0.20, 0.15, 0.10, 0.20, 0.10). These serve as an initial heuristic, not proof that physical attributes dominate, since the combined weight Х+Н is less than the combined weight О+К.

Notation note (harmonization with the paired studies). О (base) and К (acidity) retain the roles assigned in the ИЩ and ИБ indices [30], [31]. The letter Т, used for simmering/sautéing technology in the paired studies, is not used here: okroshka lacks integrative heat treatment, and its absence distinguishes it from borscht in the paired model [31]. The solid filling is designated П rather than М: project-wide, М is reserved for the external accompaniments layer (Section 3.9), resolving a collision analogously to the Р/Ц separation in [31]. Carbonation (Г) and pungent seasoning (Тр) are modifiers, not axes (Sections 3.3–3.4).

Operationalization of scales. For the pilot illustration, five axes are scored on anchored three-point ordinal scales, while О is calculated from the matrix-similarity formula above. Equal numerical steps of 0–0.5–1 do not establish equal psychological distances. The primary model enters physical measurements and the components of z separately; SSTIO is not the primary confirmatory model:

- О: continuous similarity from 0 to 1 to the nearest reference matrix; all components of z and the distance to each center are also published, to prevent the aggregate from concealing opposing changes in solids, fat, and rheology;
- Х: 0—warm/hot serving (>25 °C); 0.5—room temperature (15–25 °C); 1—cold (4–12 °C, with or without ice). Anchors reflect culinary practice, but conceptually serving temperature is a continuous physical variable; the three-point scale is a working approximation pending data;
- Н: 0—coarse cut (>12 mm) or whole pieces; 0.5—medium cut (8–12 mm); 1—fine cut (3–7 mm), herbs chopped;
- П: 0—no solid filling; 0.5—egg/potato only; 1—complete filling (meat/fish + egg ± potato);
- К: 0—no acidic component; 0.5—background acidity; 1—pronounced acidity;
- З: 0—no fresh greens; 0.5—a single component (cucumber alone or dill alone); 1—complete fresh set (cucumber + onion + dill ± radish, aromatic herbs).

Model status. SSTIO is an illustrative typicality heuristic, not a calibrated membership instrument. The weights w = (0.25, 0.20, 0.15, 0.10, 0.20, 0.10), candidate physical threshold, and SSTIO ≥0.6 are used only to generate pilot contrasts and are not regarded as empirically confirmed. The main evaluation compares precisely specified Т1–Т3 models from Section 7 on an ordinal outcome, without ROC or binarization of

similarity. Robustness is checked against deletion of each component, equal weights, monotonic splines, and a model with separate physical predictors. If SSTIO fails to improve external prediction, it is discarded without affecting the distinct measurements of membership and similarity.

Collinearity of axes. As in the paired studies, multifunctional carriers create correlation among axes: kvass changes О, К, and modifier Г; kefir changes О, К, and fat phase; radish changes Н, З, and Тр (Section 4.2). Regression-estimated weights on correlated predictors are unstable. Calibration therefore includes VIF diagnostics and, for substantial collinearity, ridge regularization or a latent-variable formulation, using the same assumption and remedy as [30], [31].

Mapping the type code to the index. The code Ок = (О, Х, Н, П, К) from Section 4.4 and SSTIO are distinct instruments; their mapping is explicit to avoid double counting:

Type-code coordinate	Index axis	Nature of mapping
О (base type, О1–О7)	О (base)	nonidentity: code describes stated base type; index uses nonacid measurements to establish matrix similarity
Х (temperature class, Х1–Х3)	Х (coldness)	direct: temperature class determines location on the scale
Н (structure, Н1–Н5)	Н (cutting)	Н1–Н4 map by actual particle size; puréed Н5 receives Н = 0
П (filling type, П0–П6)	П (filling)	partial: code distinguishes *kind*; axis measures *completeness* of solids
К (acid source, К1–К6)	К (acidity)	source defines the compositional acid profile C_rel [30]; axis К measures *intensity*, not origin
—	З (herbs)	an axis without a code coordinate: the fresh-green layer varies within types and is omitted from the code as a recurring background of the category

The type code describes recipe configuration; the index measures structural–sensory typicality. Neither individually establishes cultural membership.

In the pilot model, samples enter the working region of high typicality when passing the candidate physical threshold and SSTIO threshold; this is not a rule for category assignment. The central testable proposition is:

> ***[Д → Г]*** *Sources show that kvass was historically not the only documented base.* ***[Г]*** *Its combination of acidity, extractive body, sweetness, and possible carbonation makes it a strong candidate carrier of high typicality within the kvass branch. Whether it is optional for the modern category, and why it predominates, require separate membership testing and cannot be deduced from its chemical profile.*

[Г] The model organizes documented and proposed diversity: classic kvass-based, kefir-based, mineral-water-based, fasting, beet, historical fish, and "sour shchi" variants [6]. Their proposed positions on the SSTIO scale are predictions, not observations.

8.1. Typicality and membership: two levels that must not be conflated

A candidate two-stage description of structural typicality is compared with a continuous, threshold-free model:

1. **Candidate physical-typicality threshold:** X ≥0.5 and H ≥0.5. The value 0.5 has not been measured, and with present anchors it admits room temperature; this is only a preliminary specification. A threshold is supported only if T2 consistently outperforms T1 on independent recipes and respondent groups. Even a confirmed typicality threshold is not a necessary condition for membership without support from H2b.
2. **Candidate aggregate score:** SSTIO ≥0.6 denotes a pilot high-typicality region, and 0.4–<0.6 an intermediate region. These intervals have no ontological status and are not applied to historical cases without uncertainty analysis of coding.

Working principle for structural comparisons with neighboring categories. The formula "a cold assembled soup of finely chopped ingredients in an acidic liquid base" describes a prototypical configuration but does not establish a cultural boundary. The following cases therefore illustrate structural distances, not proven membership or exclusion:

- shchi and borscht usually have low structural proximity on X and involve integrative heat treatment [30], [31];
- gazpacho is close on X, but puréed structure is coded H = 0, reducing SSTIO and making it a convergent structural control;
- classic cold beet soup uses a beet-decoction base (a different O), with coarse or grated cutting; the paired study codes cold beet soup inside the borscht system (Ц1·К1·Б4·Т4·С2 [31]). Structurally it is cold-served borscht, not assembled okroshka;
- botvinya contains cooked rather than fresh greens, fish filling, and a scalded acidic preparation [8]: a historically attested structural neighbor without an established direct line of descent for okroshka;
- tyurya uses bread crumbs for its solid portion: a typologically close historical form but not a documented genealogical predecessor of okroshka [9];
- tarator has a fermented-milk base, cucumber, fine chopping or grating, cold serving, and sometimes ice [10]. Structurally it may score high on SSTIO, but belongs to another (Balkan) tradition, with garlic, nuts, and oil instead of meat filling—a canonical divergence between the two model levels;
- šaltibarščiai uses kefir or buttermilk, cooked beet (puréed or grated rather than chopped), cucumber, egg, and coldness [11]. It is structurally close to kefir okroshka with beet, but beet makes it primarily a *beet* soup (similarity to okroshka being limited by the common fermented-milk base and coldness), while its own name and tradition classify it among "cold borschts" —a second canonical divergence;
- ovdukh is described in reference sources as an Azerbaijani cold soup made with katyk, cucumber, and herbs [28]; it is only a candidate structural control here, not an established closest analogue;
- dovga is an Azerbaijani soup of the same broader family (yogurt and herbs), but contains rice and egg cooked in the soup itself and may be served cold or hot [27]. Integrative cooking of its assembling components (rice cooked in the soup rather than added after cooking) and hot serving depart from axis X and the "assembly without heat treatment" boundary. Structurally it is more distant from okroshka than ovdukh, despite the shared idea of a fermented-milk soup with herbs;
- kholodnik is a Belarusian cold soup on kefir or beet decoction with cooked (pickled) beet, cucumber, egg, and herbs [29]. Related to šaltibarščiai, it is another representative of the convergent "beet branch" : cooked beet defines its beet identity, while resemblance to okroshka is restricted to base, cold serving, and the cucumber–egg–herb combination.

Two levels of the model. As in the paired studies, these are distinguished:

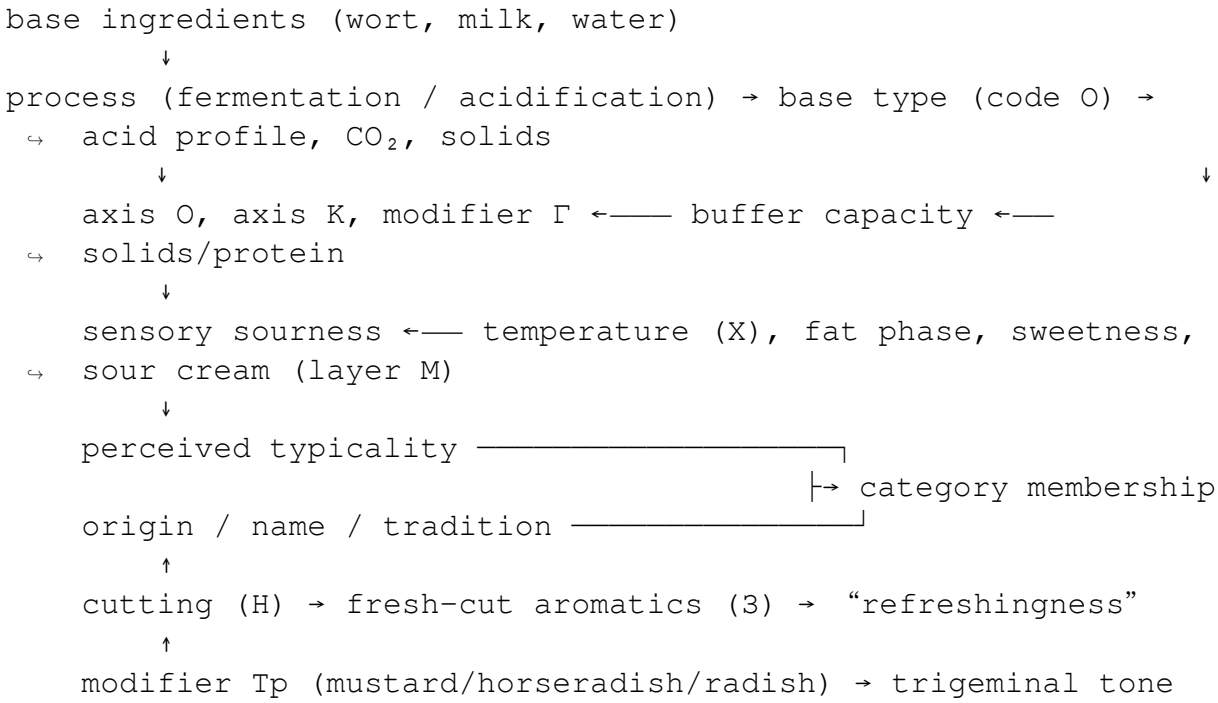
1. **Structural–sensory typicality:** the degree to which the dish matches model parameters (axes and SSTIO), a continuous quantity intended for empirical calibration.

2. **Historical–cultural membership:** the combination of naming practices, documented recipe attestations, and the distribution of cultural-panel responses. It is evaluated with uncertainty; no single indicator determines it automatically.

A structurally similar sample from a different tradition may not be called "okroshka," while a warmed canonical recipe may retain membership despite low prototype similarity. This is a testable double dissociation and the central counterexample to identifying SSTIO with membership. Prototype structure in Rosch [25] concerns similarity, whereas name use and cultural context form a separate level [24].

8.2. Candidate causal scheme of the model

[Г] Proposed relationships among system variables (mirroring the paired work [31]); arrows are hypotheses, not established causal effects:



Confounding pathways and controls are summarized in Section 7: base sweetness, carbonation, fat content, base color, cut freshness, and the taster's habitual base. The arrow from similarity to membership is a testable rather than established causal link. Blind tasting measures responses to stimuli in restricted context; the information test measures shifts in judgment when history is communicated, but does not establish actual genealogy as the mechanism.

8.3. The model's place in the triad: three category configurations

[Г] SSTIO forms a methodological triad with the shchi index ИЩ [30] and borscht index ИБ [31]; these models are not reducible to each other:

Parameter	ИЩ (shchi)	ИБ (borscht)	SSTIO / ИСТО (okroshka)
Candidate principal predictor	cooking technology (simmering), vegetable mass	flavor balance (K, S_1)	physical typicality parameters (X, H)
Candidate threshold	none	candidate sweet–sour block; numeric filter K ≥0.5 and S_1 ≥0.5 from revision 1.0 [31] withdrawn	physical-typicality threshold X ≥0.5 and H ≥0.5

Parameter	ИЩ (shchi)	ИБ (borscht)	SSTIO / ИСТО (okroshka)
Working index threshold	none (threshold-free model)	not established; numerical ИБ ≥0.6 from revision 1.0 [31] withdrawn	SSTIO ≥0.6; not a membership threshold
Acidity	optional axis; weight unknown before calibration [30]	candidate strong predictor; obligatoriness not established [31]	variable axis with replaceable carrier (axis K + code O)
Multifunctional carrier	sauerkraut (V, K, T)	beet (Ц[1], S_1, S_2, T)	kvass (O, K, Г)
Type code	Щ = (O, V, K, T, N)	Б = (Ц, К, Б, Т, С)	Ок = (О, Х, Н, П, К)
Convergent analogue/control	kapusnyak	gazpacho / luosontang	tarator / šaltibarščiai / gazpacho

Table note. The multifunctional-carrier row for SSTIO includes carbonation (Г), which is a modifier, not an index axis. Kvass covers axes O and K and modifier Г, but not X, H, П, or З. Identical letters need not designate the same measurement across models: O ranges from "water → rich broth" in ИЩ but from "neutral water → fermented acidic base" in SSTIO. For joint reading, distinguish O_щ, O_б, and O_ок. Comparing the indices does not imply that they measure the same ontological status of a category.

The three studies' hypotheses are mirrored and cross-testable. Acidity is proposed as an optional shchi axis whose weight is unknown before calibration, a candidate strong predictor for borscht, and an axis with a replaceable carrier for okroshka. The compensatory architecture is shared (P6, borscht H8, and present H8); cross-category tests (removing acid from all three dishes; serving okroshka hot) are possible within one restaurant experimental cycle (Section 7). Full comparison of these architectures belongs to a joint methodological paper; this table is preparatory. The appealing symmetry of three configurations (no filter / flavor filter / physical filter) is explicitly **a hypothesis of the trilogy, not an established fact**. The models may have been partially selected to fit that symmetry, and the experimental program may overturn it.

9. Discussion

9.1. Okroshka as a substitution system. Sources document kvass, brines, and composite acidic liquids, while contemporary practice motivates testing fermented-milk and acidified-water variants. This does not demonstrate equal prototype similarity or membership. The combination "acidic base + coldness + fine cutting" is a candidate formula for high similarity. The strongest claim of this study is not that the formula defines the category, but that it can be translated into measurable attributes and compared against a contextual model of judgment. Fluidity has not yet been operationalized and may prove to be an omitted axis. Resemblance to tyurya is typological, not an established genealogy [9].

9.2. Category multimodality with a hypothesis of two principal centers. Kvass- and kefir-based branches differ not only in acidity source but in their entire organoleptic architecture: bread kvass contributes CO_2, bread–malt aroma, and mild sweetness; kefir contributes a lactic-acid profile, creamy texture, and usually weaker and more variable carbonation. H4 predicts that tasters recognize both branches as "okroshka" while their prototypical centers of gravity are statistically separated in sensory space. A third center (mineral water plus sour cream) is also possible; hence the term "multimodality with a hypothesis of two principal centers," not "bimodality" (tested through mixture modeling; Section 7). If confirmed, the category would be semantically unified but sensorially multimodal, an interesting case for prototype theory [25]: one verbal designation encompasses two prototype centers united by a structural (physical), not flavor, invariant. This contrasts with the paired borscht model, which proposes a single main beet–acid prototype center [31]. Empirical testing of unimodality in borscht sensory space is part of the experimental program of [31]; no results are available at the time of this revision.

9.3. Hypothesis of enhanced trigeminal involvement in okroshka within the triad. Kvass-based okroshka with mustard–horseradish dressing potentially combines three sensory pathways: (a) gustatory and somatosensory components of CO_2 perception, with the gustatory pathway involving sour-sensing taste cells and carbonic anhydrase 4 [17]; (b) TRPA1-sensitive isothiocyanates from mustard and horseradish [20]; and (c) cold thermoreception. The comparative proposition that okroshka involves more trigeminal stimulation than shchi or borscht remains a hypothesis and requires a standardized direct test of all three dishes.

9.4. Category boundaries and cross-cultural parallels. Reference descriptions of tarator and šaltibarščiai motivate comparative stimuli with the structural formula "cold assembled soup on an acidic base" [10; 11], but do not establish independent origins or precise historical connections between traditions. A structurally close sample bearing another stable name and a warmed canonical recipe constitute a potential double dissociation. SSTIO is therefore evaluated as a similarity index, with cultural membership measured as a separate outcome [24; 25].

9.5. Limitations. (1) The study has no original experimental data; the contextual-sensitivity test has been designed but not performed, so no choice can be made among physically autonomous, information–context, and hybrid models of judgment. (2) The test manipulates knowledge of common origin, not actual preparation history; it cannot identify a genealogical ontology of the dish. (3) The regulatory ranges in the table in Section 5 come from GOST standards for kvass and kefir [13; 14], while standardization across fermented-milk bases is fragmentary. (4) H1–H8 all have status [Г]; SSTIO weights and thresholds are a priori, and the index itself may underperform a model using separate measurements. (5) Historical evidence records composition and terminology, not psychological classification mechanisms; some comparison sources are reference materials and do not support claims of priority or genealogy. (6) The model targets a prespecified Russian-speaking sample; extension to regional and cross-cultural groups requires stratified validation. (7) Even a between-subjects common-origin message may elicit experimenter trust, semantic priming, and demand characteristics; direct naming is investigated separately.

9.6. Principal alternative explanations. The strongest alternative is that physical attributes determine similarity and correctness while membership judgments depend on contextual information about preparation history. This explanation is compatible with all predicted sensory effects of temperature, cutting, carbonation, and base, so ordinary blind tasting cannot refute it. The test in Section 7 directly examines information-induced changes in judgment. A positive interaction admits several mechanisms—diagnostic cueing, trust in the experimenter, semantic priming, or genuine use of history as a criterion—and cannot distinguish them without further controls. Other alternatives include familiarity with exemplars, base color, regional norms, and segmentation by habitual base.

9.7. Novelty and limits of claims to priority. The potentially novel contribution is not the general observation that okroshka varies, but the operational separation of membership, prototype similarity, and conditional correctness; formalizing SSTIO as an illustrative model of only the second outcome; and a minimal randomized test contrasting physically autonomous and information–context judgment models. Because the literature search was nonsystematic and data are lacking, priority for this combination remains provisional. The scientific contribution lies in specifying a falsifiable program and identifying precisely which mechanism the current test cannot establish, not in empirically discovering the category's structure.

10. Conclusions

1. **[Д]** Sources document multiple liquid bases, including kvass, brine, and the beverage called "sour shchi" [2], [3], [6], as well as recurrent associations in historical descriptions with cold serving and finely chopped structure. They do not establish necessary conditions of the contemporary category.

2. **[Г]** Temperature, cut size, and liquid-base properties form a measurable set of candidate predictors of similarity to typical okroshka and conditional correctness of serving. Their role as conditions of category membership remains unestablished.
3. **[Г]** The index SSTIO = $w_1 \cdot О + w_2 \cdot Х + w_3 \cdot Н + w_4 \cdot П + w_5 \cdot К + w_6 \cdot З$ is proposed with a priori weights. SSTIO is an illustrative similarity heuristic, not a membership measure; the principal test uses separate physical predictors and allows the index to be abandoned.
4. **[Г]** Physically autonomous and information–context models of category judgment make different predictions for the temperature × information interaction. A randomized between-group protocol and primary estimand δ have been specified but not tested; even a positive interaction would not prove a genealogical mechanism.
5. Kvass carbonation has gustatory and somatosensory components [17], and the regulated characteristics of kvass and kefir differ [13; 14]. Extrapolating these mechanisms to okroshka typicality and testing multimodality require direct experimentation. [Д → П → Г]
6. Historical sources [2; 3; 5; 6; 12] repeatedly attest the dish from the late eighteenth century onward and document a kvass-based recipe tradition, but contain no evidence of a psychological classification mechanism. [Д]
7. An H1–H8 research program has been formulated with independent batches, separate sensory and cultural panels, neutral membership measurements, a similarity scale, and two-part correctness analysis. It is a study proposal, not an obtained result. [Г]
8. **[Г]** A descriptive type code $О_к$ = (О, Х, Н, П, К) and similarity measures have been introduced. Their predictive value needs external calibration and does not replace cultural classification.

Use of AI Tools

In preparing the manuscript, large language models were used for editing, translation, discussion of hypotheses, and literature searching. The interpretations and conclusions are the author's own.

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(33 entries. Entries [30–31] are the author's related theoretical studies. Entries [8–11] and [26–29] are reference-type sources used only to construct comparative stimuli and questions; they do not support claims about genealogy, prevalence, or scientific priority.)

Revision History

1.0 —19 October 2026. First public edition.