RESEARCH MANUSCRIPT

Borscht as a Historically Changing Set of Named Dishes: Lexical Continuity, Structural Similarity, and a Program of Empirical Testing

---

A. N. Koriakin

Revision 1.0 — 19.10.2026

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

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

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

Contents

Abstract . . . 2
1. Introduction . . . 2
1.1. Statement of the problem . . . 2
1.2. Etymology and historical context . . . 2
1.3. Cultural significance: from the imperial table to diaspora cuisine . . . 4
1.4. Aim and objectives . . . 6
2. Materials and Methods . . . 7
3. Main Parameters of Borscht as a System . . . 8
3.1. Color . . . 8
3.2. Acidity . . . 8
3.3. Sweetness . . . 9
3.4. Earthy note (background axis) . . . 10
3.5. Base . . . 10
4. Classification of Borscht Varieties . . . 10
4.1. Existing approaches and formulation of the classification task . . . 10
4.2. Parametric classification: five recipe-and-process coordinates . . . 10
4.3. Formal type code . . . 12
4.4. Technological modifiers and serving ritual . . . 13
4.5. Similarity metric among varieties . . . 13
5. Cultivar Types and Cultivated Forms of Beet as an Experimental Variable . . . 14
5.1. Table beet . . . 14
5.2. Fodder beet . . . 15
5.3. Sugar beet . . . 15
5.4. Yellow cultivars of table beet . . . 15
5.5. Beet greens . . . 15
6. Functional Substitutes for Beet . . . 15
6.1. Swiss chard (leaf beet, *Beta vulgaris* subsp. *cicla*) . . . 15
6.2. Sorrel (*Rumex acetosa*) . . . 15
6.3. Tomatoes . . . 16
6.4. Historical precedent: hogweed . . . 16
7. Program of Experimental Testing . . . 16
Experiment 0. Preliminary survey on necessary features . . . 19
Experiment 1. Beet cultivar type as a variable . . . 19
Experiment 2. Acidity source as a variable (paired causal contrasts) . . . 20
Experiment 3. Borscht without beet (central test of the model) . . . 20
Minimal factorial test of structure H_s and reported context H_c . . . 21
Venue and schedule . . . 21
How to interpret negative results . . . 22
Traceability matrix: hypothesis → variable → experiment → falsifier . . . 22
8. Theoretical Model: the Borscht-ness Index . . . 23
8.1. Class boundaries: core, periphery, and falsifiability . . . 25
8.2. Causal scheme and confounding variables . . . 27
8.3. The model within the trilogy: three configurations of category . . . 27
9. Discussion . . . 28
10. Conclusions . . . 29
Use of AI tools . . . 29
References . . . 29
Revision history . . . 33

Abstract

This study examines borscht as a historically changing set of dishes united by the cognate names *борщ/barszcz* and partly documented lines of recipe continuity. Historical and recipe sources show that these names have been applied to dishes without red table beet; consequently, the presence of this ingredient, a red color, or a single recipe is not a universally necessary condition for the historical and lexical use of the name. The sources presented do not establish a unified genealogy of all Polish, East Slavic, Ashkenazi, and putative diaspora variants. The widely attested red-beet variant is used as a reference specimen and a testable candidate for one of the modern prototypes, but its cognitive prototypicality is not treated as established. To describe structural similarity, a preliminary parametric classification along five recipe-and-process coordinates, a type code, a baseline metric, and a candidate "borscht-ness index" (BI) are proposed. Before validation, these describe expert-defined similarity rather than measuring cultural membership. The food chemistry of betalains, organic acids, sugars, and geosmin motivates measurable characteristics; however, results obtained with juices, extracts, or isolated components are not presented as results obtained with finished borscht. A hypothesis concerning the effect of the physical structure of a sample is distinguished from a hypothesis concerning the effect of reported provenance information on categorical decisions. The proposed factorial test can estimate these two effects for a particular pair of dishes, but it does not randomize the actual history of a recipe and therefore does not directly test historical genealogy. The test has not been conducted. This work contains no original empirical results. Its established finding is limited to heterogeneity in the historical and lexical use of the name and documented continuity of individual lines; unified genealogy, the number of prototypes, the structural mechanism, weights, thresholds, and the definitive set of axes remain hypotheses.

Keywords: borscht; beet; betalains; betacyanins; acidity; geosmin; culinary classification; sensory analysis; CIELAB; culinary history; diaspora cuisine.

---

1. Introduction

1.1. Statement of the problem

In popular understanding, borscht is defined as a soup with beet. This definition also appears in reference works: Encyclopædia Britannica describes borscht as a "beet soup of the Slavic countries" [1]. Culinary reality is broader than this dictionary definition. Borscht variants include:

- versions without beet (green sorrel borscht, white borscht);
- versions in which beet is replaced by other plants (tomatoes, Swiss chard, beet greens);
- versions using different types of beet (table, fodder, sugar beet);
- versions with different acidity sources (vinegar, lemon juice, kvass, cabbage brine, tomatoes, sorrel);
- versions with fundamentally different sweetness–acidity balances (from slightly sweet to sharply sour variants based on beet kvass).

Some of these names are firmly attested in different traditions, but category boundaries may differ across linguistic and cultural groups. The central question therefore cannot be answered by recipe composition or the author's intuition alone:

> ***Which observable features describe similarity to reference borscht variants, how do physical profile and cultural context affect contemporary categorical decisions, and which historical lines of name usage are actually documented?***

1.2. Etymology and historical context

It is revealing that the name of the dish itself does not refer to beet. According to historical and etymological dictionaries, the word *borscht* originally designated a plant—common hogweed (*Heracleum sphondylium*),

whose edible leaves and stems were used for food [1], [2]. The culinary use of hogweed in the region is documented by primary sources: in *The Herball, or Generall Historie of Plantes* (1597), the English botanist John Gerard recorded that people in Poland and Lithuania made a fermented drink from a decoction of this herb inoculated with sourdough, which they drank in place of beer [3]. Research into medieval Polish cuisine confirms that fermented hogweed stems and leaves were used to prepare a sour soup from which the dish took its name [4].

Importantly, even in early usage the term was not tied to one particular ingredient. In nineteenth-century rural Poland, *barszcz* denoted all kinds of sour soups made with barberries, gooseberries, currants, cranberries, plums, or celery [4]. The first dictionary definition of *barszcz* as a "sour soup made from fermented beet" is recorded only in Jerzy Samuel Bandtkie' s Polish–German dictionary of 1806 [5]. Beet thus historically displaced hogweed as a carrier of the sour-vegetable profile [1], [4], while the culinary use of hogweed continued to be noted in the traditional cuisines of Eastern European peoples into modern times [3], [4], [6].

Documentary records from the sixteenth and seventeenth centuries add two strands of evidence. In an excerpt from the Novgorod postal-station books (1586–1631) published in a manuscript, palace gardeners are instructed to supply "fresh and salted cucumbers and cabbage, onions and garlic, mustard, carrots, radishes, beets for setting brines, borscht, and every garden vegetable" [43]. This passage accords with the use of "borscht" as a plant name. The edition has been identified ([43]: *Novgorod Postal-Station Books*, edited by I. Ya. Gurlyand, Yaroslavl, 1900), and the quotation checked against its full text; pending verification of the page in a copy, the passage is used as supporting evidence. One of the early mentions known to the author of borscht specifically as a prepared dish dates from 1584: the Danzig commercial agent Martin Gruneweg, passing through Kyiv on his way from Lviv to Moscow, wrote that the Ruthenians "rarely or never buy borscht, because everyone prepares it at home," as it was their "everyday food and drink" [44]. The source does not give a recipe, and no claim of absolute chronological priority is made without a systematic search. *Domostroi* (mid-sixteenth century) not only recommends "sowing borscht" [40] but prescribes household fermentation as an ordinary provisioning practice: "in autumn, salt cabbage and set beet brine" [40]. This is an early written record of beet brine as a prepared product, not proof that it was used specifically in borscht.

Caveat on evidentiary value. This historical observation is directly relevant to the present study, but its status requires precision. Etymology and documentary history provide a **historical argument for the broad semantics of a class**, not proof of the structure of a modern dish: the fact that a word once denoted a broader set of sour soups does not automatically mean that modern borscht retains that structure. The latter must be tested by chemistry and experiment, not etymology (Sections 3 and 7).

A crucial semantic distinction is also established here, without which the classification problem is underdetermined. The study distinguishes **two objects**: (A) the historical–lexical *barszcz/борщ* family, a changing set of named dishes; and (B) one or more contemporary sensory prototypes, among which the red-beet variant is especially prominent. The parametric model of Sections 4 and 8 describes object B. Object A is established by source criticism and naming practices and cannot be inferred from BI. This study does not claim that a modern prototype arose through selecting the "most effective" carrier of functions: evidence is insufficient for that causal historical inference.

Thus, etymological and documentary evidence supports a limited conclusion: historical and modern uses of the names *борщ/barszcz* for dishes without red table beet are known, so this ingredient is not a universally necessary condition for all attested uses of the name. The sources document lexical continuity and specific recipe lineages, but do not establish a unified genealogy of all variants. Nor do they prove sensory substitutability of beet or the existence of a single "required" flavor profile; these are separate testable hypotheses.

Botanical clarification and safety note. *Historical sources associate the name primarily with common hogweed (*Heracleum sphondylium *L.;* H. sibiricum *was also used in Siberia), rather than Sosnowsky's hogweed (*H. sosnowskyi *Manden.), introduced into the USSR. The sap of plants of the genus* Heracleum *may contain photosensitizing furanocoumarins; the historical account should therefore not be read as practical advice to gather or cook wild hogweed. Available sources document fermented and boiled preparations, but this study does not establish the safety of any particular species, plant part, or processing method.*

1.3. Cultural significance: from the imperial table to diaspora cuisine

The name "borscht" is attested at different levels of the culinary hierarchy and has been applied to substantially different recipe forms. Such persistence is compatible with cultural continuity of individual lineages, but does not by itself establish either a unified genealogy of all variants or a sensory mechanism preserving identity.

Imperial integration and the formation of the "Russian cuisine" canon. One of the early printed descriptions of borscht in domestic culinary literature known to the author appears in Sergei Drukovtsov's *Culinary Notes* (1779) [7]; absolute priority is not established by this nonsystematic review. As historian Alison Smith shows in *Recipes for Russia: Food and Nationhood under the Tsars*, in the eighteenth and nineteenth centuries dishes from different territorial traditions were incorporated into an empire-wide culinary canon understood as "Russian cuisine" [8]. Regional attributions were retained (for example, Elena Molokhovets lists "Little Russian borscht" and "Polish borscht" [9]). Soviet prescriptive literature continued incorporating borscht variants into the common canon: *The Book of Tasty and Healthy Food* (1939) contains numerous recipes [10]. These sources document canonization in Russian and Soviet culinary literature, but do not establish its sole cause or exact duration.

The imperial table. Borscht opened the coronation dinner of Nicholas II on 26 May 1896 in the Alexander Hall of the Grand Kremlin Palace: in the menu designed by Viktor Vasnetsov and now held by the Victoria and Albert Museum in London, the first course is listed as "borsch and pepper-pot soup" [11]. According to contemporaries, Alexander III introduced *bortchok*—a Lenten borscht on porcini broth—into the court kitchen menu [12]. Earlier still, during the Paris peace negotiations of 1815, Alexander I instructed the celebrated French chef Marie-Antoine Carême to serve diplomats a Russian national soup as a demonstrative gesture of cultural identity [13]. The mutual influence of French haute cuisine and the Russian soup tradition produced the aristocratic "bortchok"—a clear ruby-red beet consommé served in bouillon cups [13]; the technique of ennobling borscht with wine is also recorded in domestic culinary classics (Molokhovets's "Borscht from Baked Beet with Wine") [9].

Culinary classics as evidence of variability. Editions of Elena Molokhovets's *A Gift to Young Housewives* (first published in 1861, with the recipe corpus expanding between editions) contain at least seven distinct variants of borscht: Little Russian (with kvass), Polish, baked-beet borscht with wine, celery borscht, Lenten borscht with *uszka*, crucian-carp borscht, and others [9]. Thus, the variability of borscht as a class of dishes is documented within a single authoritative source more than a century and a half old.

Borscht in written monuments and literature. One of the early Russian uses of the word "borscht" known to the author dates to the mid-sixteenth century and still denotes the plant rather than the dish: *Domostroi* advises that "borscht should be sown by the fence, around the whole garden" [40]. In V. I. Dahl's dictionary (1863–1866), the word occurs both as the name of a plant and as the name of a dish [41]. No proverbs containing the word *borscht* were found in Dahl's *Proverbs of the Russian People* (1862) [41]; this characterizes the examined corpus but does not date the dish's cultural canonization.

Literature records borscht not as a festive dish but as an everyday one—a marker of domestic prosperity and household competence: a corpus analysis of the Russian National Corpus counts 1,127 occurrences of the word in 608 documents of the main corpus [41]. The chronological chain of references includes N. V. Gogol— "a good borscht with pigeons, which Gapka had cooked" (*The Tale of How Ivan Ivanovich*

Quarreled with Ivan Nikiforovich, 1835); G. F. Kvitka-Osnovianenko, who as early as 1840 lists an entire typology of the dish (“borscht with fattened poultry···Sobieski borscht···Skoropadsky borscht···Pechersk fish borscht” —*Pan Khalyavsky*), so that multiplicity of variants was recorded in fiction long before culinary classifications [41]; and I. S. Turgenev, who places borscht alongside shchi as the two basic soups of the Russian table (“How might one find out, dear fellow, what Yenyusha wants for dinner today, shchi or borscht?” —*Fathers and Sons*, 1862). Later examples include A. I. Kuprin (*The Wonderful Doctor*, 1897) and V. Grossman (*Life and Fate*: “borscht with pork on weekdays and holidays alike”) [41]. In a folk Cossack ballad about a mother’s heart, refusal of the table begins specifically with borscht: “From that day the Cossack fell silent and gloomy, ate no borscht, ate no salamata.”

Diaspora cuisine. In Ashkenazi Jewish cuisine, borscht became one of the central soups; the widespread English spelling *borscht* derives through the Yiddish spelling בָּארשט [14]. Adaptation to the laws of kashrut produced distinct subclasses: a vegetarian borscht (without meat broth) or a dairy version with smetana—both avoiding the combination of meat and dairy [14]. Its root-vegetable base made borscht an ideal dish for early-spring Passover, when long-stored beets and cabbage remained available, while dairy borscht with smetana corresponded to the tradition of Shavuot [14]. The diaspora tradition also preserved a regional flavor axis: according to culinary scholar Claudia Roden, Polish Jews preferred sweeter borscht, while Lithuanian Jews preferred it more sour [15], [16]. An extreme case of cultural metonymy is the American **Borscht Belt**: a network of summer resorts in the Catskill Mountains north of New York City that hosted Ashkenazi families from the 1920s through the 1970s (at its peak, up to 500 hotels and bungalow colonies with kosher kitchens). The network took its nickname from the dish, in playful analogy with the “Bible Belt” of the southern United States; the era was immortalized in the film *Dirty Dancing* (1987) [42]. A dish thus gave its name to an entire geographic region—a rare precedent in culinary toponymy.

The Far Eastern branch. After 1917, Russian émigrés brought borscht to Harbin and Shanghai. In Shanghai, where as many as 21,000 Russian refugees lived in the 1920s and 1930s and Avenue Joffre, lined with dozens of Russian restaurants, acquired the nickname “Russian Road,” the dish transformed into *luosong tang* (罗宋汤, “Russian soup”). Beet was replaced there with cabbage and tomatoes, including industrial tomato paste [17]. A frequently repeated explanation invoking the climatic impossibility of growing beet remains a conjecture not supported agronomically in the cited source (see Section 6.3). *Luosong tang* entered the classics of Shanghai *haipai* (“Western-style”) cuisine, spread throughout China, and later migrated with Shanghai chefs to Hong Kong and onward to North America [17]. Thus, history itself conducted an “experiment in replacing beet with tomatoes” —and the dish retained the identity of “Russian soup” without a single gram of beet.

Limit of distribution. Borscht even crossed the Earth’s atmosphere: a tube of borscht prepared for Soviet cosmonauts is exhibited at the Smithsonian National Air and Space Museum in the United States [14].

The limited conclusion of this review is that the name and cultural line of borscht persisted despite substantial compositional changes in several traditions. This rules out a universal definition based on one mandatory ingredient, but does not establish that the structure proposed below carries identity: persistence of a name may instead involve genealogy, linguistic borrowing, social memory, or combinations of these factors.

Summary table of historical evidence. In keeping with the caveat on evidentiary value (Section 1.2), each historical fact is paired with what it permits one to infer and what it does **not** prove:

Fact	What it permits one to infer	What it does NOT prove
The word “borscht” originally denoted hogweed; sour soup made from it is documented [1]–[4]	historical change in the referent of the name	functional or sensory equivalence of hogweed and beet

Fact	What it permits one to infer	What it does NOT prove
In the nineteenth century *barszcz* was a generic designation for various sour soups [4]	broad historical semantics of the term	the structure of the modern family and the causal mechanism of its boundaries
Postal-station books (1586–1631): “beets for making brines”; “borscht” in the list of garden crops [43]	beet as raw material for brine; “borscht” still as a plant name	composition of the prepared dish; that the brine was used specifically in borscht
Gruneweg (1584, Kyiv): borscht was “daily food and drink” that everyone prepared at home [44]	existence of borscht as a prepared liquid everyday dish already in the sixteenth century	the recipe and composition of that dish, including whether it contained beet
Domostroi: “sow borscht”; “in autumn, salt cabbage and set beet brine” [40]	household fermentation, including beet brine, as a normal sixteenth-century practice	the recipe and acid profile of dishes in which the brine was used
Dictionary fixation of the beet norm in 1806 [5]	late canonization of beet	that beet borscht did not exist before 1806
Cookbook multiplicity from the eighteenth and nineteenth centuries (Drukovtsov, Molokhovets) [7], [9]	stability of the dish as a class of variants	the boundaries of that class
Ashkenazi adaptation to kashrut (meatless/dairy borscht) [14]	preservation of identity when the base changes	that axis O is optional for all tradition bearers
Tomato-based variants of *luosong tang* are documented as a Chinese adaptation of “Russian soup” [17]	a possible genealogical transformation and motivation for H2	that *luosong tang* is borscht or that tomatoes replace beet in sensory terms
Absence of proverbs containing “borscht” in Dahl (1862) [41]	absence of documentation in this particular corpus	the age of the dish or date of its cultural canonization
Imperial and Soviet canonization [8], [10]; coronation menu [11]	high cultural status of the dish	any conclusions about its chemical-sensory structure

1.4. Aim and objectives

The aim of the study is to establish the most defensible boundary between documented historical–lexical use of the name, partly reconstructable continuity of individual recipe lineages, and hypothetical mechanisms of contemporary categorization, and to develop a future method for measuring the **degree of structural similarity of a dish to an empirically defined prototype**. The claim that no single ingredient is necessary is supported by documented beet-free named variants; a unified genealogy of the entire set, a single prototype, necessary sensory functions, and the causal contribution of structure to categorical decisions require separate testing.

Objectives:

1. Identify and describe the functional parameters of the system (color, acidity, sweetness, base, technology).
2. Construct a classification of borscht types using these parameters.
3. Analyze beet types as an independent variable using chemical-composition data.
4. Examine functional substitutes for beet, including historical precedents (hogweed, *luosong tang*).
5. Formulate a theoretical model (the “borscht-ness index”).
6. Develop a program of experimental testing with objective metrics.

Relationship to the paired study. This investigation forms a methodological pair with the study of the acid–flavor profile of traditional shchi [45]. Despite a common framework (functional carriers, a multi-axis prototype model, and falsifiable predictions), the subjects differ: borscht centers on color and sour–

sweet balance, whereas shchi centers on the multidimensional acid profile and fermentation. Shared tools (decomposition of the acid profile, differentiation of chemical and sensory scales of acidity, mechanisms governing perceived acidity, and buffering capacity) are developed in [45] and adopted here by reference, without repetition.

Status of the work. This is a theoretical–analytical study and protocol; neither an original experiment nor a systematic recipe-corpus collection has been performed. The factorial test proposed below has likewise not been conducted: it estimates effects of the physical profile and reported provenance on participants' decisions but does not randomize the actual history of recipes. Consequently, there are no empirically estimated weights, thresholds, effect sizes, demonstrated sensory mechanism, or established unified genealogy. Markers denote: **[D]** —a claim directly supported by the cited source within the system it examined; **[T]** — transfer of results to finished borscht or another matrix; **[H]** —the author' s own testable hypothesis. [D] does not mean that a source automatically supports a broader causal inference.

---

2. Materials and Methods

This is a theoretical–analytical investigation with a proposed empirical test. It is not a systematic review: the literature and historical-source search followed no prospectively published protocol, and no databases, search strings, cutoff dates, or dual-screening procedure were specified. Accordingly, claims of "not found in the literature" and of priority are preliminary rather than exhaustive.

Methods:

1. **Analysis of scientific literature** on beet pigments (betalains), color stability, the composition of different beet types, acidity of fermented foods, sensory analysis, and historical culinary sources.
2. **Comparative classification** of known borscht variants by selected parameters, including historical and diaspora branches.
3. **Modeling** of a formalized "borscht-ness index."
4. **Experimental-series design** specifying a reproducible procedure with objective metrics:
   - **CIELAB colorimetry** (L, *a*, b* coordinates), a standard method of food color assessment [18];
   - **pH measurement and titratable acidity** of broth;
   - **sensory analysis** (descriptive profiling and scales for acidity, sweetness, earthiness, and broth richness).
5. **Preliminary operationalization of the category** by separating three non-interchangeable types of data: (a) the documented name and genealogy of a variant; (b) instrumentally and sensorially measured properties of a sample; and (c) a participant' s "borscht / not borscht" decision. Until these data are obtained, functional axes represent a proposed coding scheme rather than a discovered natural class structure.
6. **Testing identifiability of categorical-decision mechanisms:** identifying a case where documented naming and structural similarity may diverge; formulating the structural-effect hypothesis H_s and contextual-effect hypothesis H_c; and designing a minimal factorial test with independent manipulation of physical profile and reported provenance. The historical–genealogical hypothesis H^g is evaluated separately by source-critical comparison of actual lineages and is not equated with H_c. This stage is logical and methodological analysis, not a completed experiment.

Required pre-experimental stage. A prospectively specified corpus of recipes must be assembled from historical cookbooks, standard recipe collections, and contemporary traditions. Inclusion criteria, the unit of analysis (recipe, edition, or regional type), independent double coding of axes, discrepancy-resolution rules, and inter-rater agreement are required. Without such a corpus, feature frequencies, co-occurrence, stability of the five coordinates, and completeness of the typology cannot be evaluated.

Source-critical note. Sources occupy three functional layers: (a) peer-reviewed scientific articles supporting chemical and sensory claims [18]–[34]; (b) institutional and academic works (encyclopedias, museums, university monographs, dictionaries, classic cookbooks) supporting historical facts [1]–[17], [35], [36], [53], [54]; and (c) primary documents of living traditions (family recipes and personal communications [37], [38]), used solely as ethnographic samples of practice, not as grounds for theoretical claims. The evidentiary hierarchy follows the paired study [45] and is applied throughout the text: **[D]** —established by sources, mainly layers (a) and (b); **[T]** —plausible but untested transfer of adjacent-domain findings to borscht; **[H]** —the author's hypothesis. Historical and cultural evidence supports limited conclusions concerning names and recipe variation, not a sensory or causal categorization mechanism.

---

3. Main Parameters of Borscht as a System

3.1. Color

[D] The red color of classic borscht is due to **betalain** pigments—water-soluble nitrogenous compounds found in plants of the order Caryophyllales that functionally replace anthocyanins [19], [20]. Betalains comprise two classes:

- **betacyanins** (red-violet; predominantly betanin, responsible for 75–95% of beet's red coloration);
- **betaxanthins** (yellow-orange; predominantly vulgaxanthin I) [21], [22].

[D] The key culinary property of betalains is that **stability depends on pH, temperature, heating duration, and matrix composition**. Reviews and model experiments typically identify a mildly acidic range of relatively high betanin stability; the actual degradation rate also depends on oxygen, light, water activity, pigment identity, and medium composition [19], [23], [24]. Study [23], for example, examines an encapsulated extract rather than soup and cannot establish a universal "optimal pH for borscht."Degradation generally accelerates in alkaline conditions and with prolonged heating [19], [23], [24], but kinetics must be measured directly in a standardized borscht matrix.

[D → T] Implication for the borscht system: an acidic component contributes taste and may alter pigment preservation. The culinary practice of adding acid while processing beet is consistent with this mechanism but does not isolate it from heat exposure, oxygen, or matrix composition. The color-related role of acidity in finished borscht and its categorical importance therefore require separate testing.

An association between instrumental color and betalain content has been demonstrated for certain thermally processed beet products [25], but calibration is matrix-dependent. CIELAB may therefore provide a nondestructive observable indicator but cannot replace direct chemical analysis when testing the mechanism.

[T] An empirical technique to limit pigment degradation. Soviet cookbooks of the 1940s–1950s describe preparing a separate beet infusion added towards the end of cooking. This is consistent with reducing cumulative thermal exposure and managing pH. The reported loss of 51% of betacyanins after 180 seconds in one particular experiment [24] cannot be quantitatively extrapolated to borscht: raw-material geometry, medium, and heating conditions differed. Thus the historical technique is considered chemically motivated, but its effectiveness in borscht remains to be measured rather than taken as proven.

3.2. Acidity

[D] Sources of acidity in borscht are diverse:

Source	Acid type	Note
Sauerkraut, cabbage brine	Predominantly lactic; other acids and metabolites also occur	A community of lactic acid bacteria drives fermentation; composition depends on raw materials, salt, temperature, and process stage [26]
Vinegar	Acetic	Rapid acidification during beet sautéing
Lemon juice, citric acid	Citric	Listed by Britannica among standard acidifiers, alongside vinegar and kvass [1]
Kvass (bread or beet)	Lactic + acetic (fermentation)	Britannica identifies kvass as a classic counterbalance to beet sweetness [1]; Molokhovets uses kvass as a borscht base [9]
Tomatoes	Citric, malic	A source of acidity, color, and sweetness simultaneously
Sorrel	Oxalic (oxalate)	Basis of green borscht; its characteristic sour flavor is associated with high oxalate content [27]
Sour berries and fruit	Various organic acids	Regional versions; sour soups of the historical *barszcz* type used barberries, gooseberries, currants, and plums [4]

These sources differ in more than their molecules. The paired shchi study [45, Section 3.1] proposes a decomposition of the acid profile into a chemical block C_abs/C_rel (absolute acid concentrations and relative acid composition) and a sensory profile A_s = (I, D, P, R): intensity, duration, temporal position, and character. This framework can be applied to borscht without modification. The question of whether different acidifiers are sensorially equivalent at equal pH is equally relevant to borscht and shchi and is addressed here using the same tool (Experiment 2, Section 7).

[D → T] Beet kvass: microbiology and beet-fermentation chemistry. Beet kvass is produced by spontaneous or starter-mediated lactic acid fermentation; the microbial community and metabolite composition depend on the process. Betalain kinetics during fermentation and storage of beet juice have been studied [21], but acid accumulation and pigment degradation occur simultaneously. Thus beet kvass supplies both acids and pigments, while the sign and magnitude of its net effect on the color of finished borscht cannot be assumed in advance. The assertion that its acid necessarily "stabilizes its own pigment" is replaced by a testable prediction.

3.3. Sweetness

[D] Sweetness comes from vegetables: beet, carrot, onion, and parsnip. Beet sugar content varies considerably by type (Section 5), from moderate amounts in table beet to 16–25 g of sucrose per 100 g in sugar beet [28], [29]. The sweetness–acidity balance is a central flavor axis: Britannica explicitly describes kvass, vinegar, and lemon juice as counterweights to beet sweetness [1]. Ethnographic reports also note regional variation, with sweeter variants preferred in the Polish Jewish tradition and more sour variants in the Lithuanian Jewish tradition [15], [16].

Adjustment of the balance in household practice. In one documented family practice [38], lemon juice supplements apple-cider vinegar if the acidity is insufficient, while sugar is added "to taste" at the end. This single ethnographic example illustrates, but does not statistically substantiate, the possibility that

cooks regulate acidity and sweetness separately. It does not justify weights or the mandatory status of axes K and S_1.

3.4. Earthy note (background axis)

[D] Beets' characteristic earthy note is caused by **geosmin** (trans-1,10-dimethyl-trans-9-decalol), a volatile compound produced by the root crop, whose content depends on the cultivar [30], [31]. Human olfaction is highly sensitive to geosmin (thresholds in the single-digit nanograms per liter); its concentration in the peel is about six times that in the flesh [30]. **[D → T]** In chemical experiments, geosmin does react under acidic conditions to form a much less odorous product traditionally described as argosmin [30]. This does not automatically establish that the usual acidity and cooking duration of borscht appreciably reduce its geosmin content or sensory contribution. For borscht, the effect of acidification on the earthy note is a separate testable hypothesis, not an established chemical argument.

3.5. Base

[D] The liquid base of borscht varies: meat broth (beef, pork, poultry), fish broth (Molokhovets gives a crucian-carp borscht [9]), mushroom broth (a Polish fasting variant uses wild-mushroom stock [1]; Alexander III' s court *bortchok* used porcini broth [12]), vegetable stock, or a kefir-beet decoction (cold borscht varieties). **[H]** The base determines richness/body of broth and the umami background (umami—the fifth basic taste, "rich" or "brothy" ; its carriers are glutamate and certain nucleotides in meat, mushrooms, and tomatoes; see the paired study [45, Section 2.3] for detail), but it does not carry a specifically "borscht" function; that role is common to the broader class of rich dressed soups.

---

4. Classification of Borscht Varieties

4.1. Existing approaches and formulation of the classification task

[T] In the literature examined nonsystematically by the author, no classification of borscht constructed specifically from the proposed functional parameters was found. This is a preliminary observation about novelty, not proof of priority. Adjacent work in computational gastronomy already employs ingredient networks and recipe-similarity measures [47], [48]. Accordingly, any novelty here can only concern borscht-specific operationalization and integration of chemical, technological, and categorical evidence. Traditional approaches to borscht primarily fall into two groups:

1. **General soup classifications** (teaching and industry literature on food-service technology): soups are classified by serving temperature (hot / cold), liquid base (broths, decoctions, milk, kvass, fermented-milk products), and method of preparation (dressed, puréed, clear) [35]. In such schemes, borscht is only one item within the group of dressed soups; these classifications do not describe the internal structure of the borscht class.
2. **Enumerative lists** in collections and encyclopedias list varieties such as "Ukrainian,""Moscow,""Siberian,""Naval," and "Polish" [36], without an explicit system of explanatory features.

The proposed classification differs from these approaches, but neither its completeness nor superiority has been demonstrated. The novelty claim is restricted to a candidate borscht-specific scheme comprising a parametric classification, formal type code, and testable proximity metric. Priority requires a systematic search, and utility must be assessed against simple baselines (Jaccard ingredient distance, technological distance, and statistically learned metrics).

4.2. Parametric classification: five recipe-and-process coordinates

[H] It is proposed as a preliminary approach to classify borscht varieties not by country of origin but by five recipe-and-process coordinates, each taking discrete values. These coordinates are not identical to the chemical-sensory parameters in Section 3 and are not statistically independent variables: one carrier

may simultaneously change several observable properties (beet: color, sweetness, and earthiness; tomatoes: color, acidity, and sweetness; acid: taste and pigment stability). The code records the source or structure of the recipe, whereas the index in Section 8 is intended for future description of measurable consequences.

Axis Ц —source of color: - Ц1 —table beet (betacyanins); - Ц2 —other carriers of beet pigments (fodder or sugar beet, yellow cultivars, beet greens, Swiss chard); - Ц3 —tomatoes (lycopene); - Ц4 —green leafy vegetables (chlorophyll: sorrel, nettle, spinach); - Ц0 —red pigment absent (white borscht varieties).

Axis К —source of acidity: - К1 —kvass (bread or beet); - К2 —sauerkraut, cabbage brine (lactic acid fermentation); - К3 —vinegar (table, apple-cider); - К4 —lemon juice, citric acid; - К5 —tomatoes; - К6 —sorrel (oxalates); - К7 —fermented-milk base (kefir, soured milk); - К8 —sour berries and fruits (historical variants—barberry, gooseberry [4]; living practice—sour apples, prunes). - К9 —fermented flour sourdough (wheat, rye, or other grain; the flour type is specified by a subtype, e.g., К9-пш. or К9-рж.). Unlike bread or beet kvass (К1), this coordinate is needed for *barszcz biały* and *żur/żurek* [53], [54].

Axis Б —type of liquid base: - Б1 —meat broth; - Б2 —fish broth; - Б3 —mushroom broth; - Б4 —vegetable stock (meatless); - Б5 —fermented-milk base.

Axis Т —method of treating beet (or its functional substitute): - Т1 —sautéing with acid; - Т2 —baking (Molokhovets' s "baked-beet" variant [9]); - Т3 —boiling directly in the broth; - Т4 —separate beet kvass/decoction subsequently combined with the base; - Т5 —slow stewing without sautéing (vegetables in their own juices, including with beet infusion added at the end—the method of Soviet recipes of the 1940s–1950s); - Т0 —not applicable.

The value Т0 requires clarification: absence of beet is not a "method of treatment" but absence of the object to be treated. Thus Т0 means "axis not applicable": the corresponding functions are then fulfilled by carriers on other axes (sorrel—Ц4·К6, tomatoes—Ц3·К5), and the substitution itself is recorded by those axes rather than by Т. This preserves homogeneity of the coordinate: all nonzero Т values describe actual technological operations.

Axis С —vegetable composition and garnish structure: - С1 —full classic set (cabbage, potato, carrot, onion); - С2 —reduced set; - С3 —expanded set (beans, bell pepper, roots); - С4 —without cabbage; - С5 —without garnish (clear serving).

Rationale for the composition and granularity of coordinates. The five code coordinates describe the source of color, the source of acidity, the liquid base, processing technology, and garnish structure. Section 3, by contrast, describes chemical-sensory properties: observed color, acidity, sweetness, earthiness, and base. There is a mapping between the two sets, but they are not identical: color source Ц affects measured color $Ц^1$; acidity source К affects chemical and sensory acidity; base Б affects О; technology Т affects Т; garnish composition С does not yet enter ВІ; sweetness S_1 and earthiness S_2 are measured directly and have no separate source coordinates in the code. This distinction prevents conflation of recipe taxonomy with the sensory model. The choice of both sets remains an expert operationalization rather than a discovered natural dimensionality of the category. Serving temperature, aroma, and textural techniques are provisionally assigned to modifiers; their exclusion must be confirmed by the corpus and external prediction.

The granularity of values within the axes is defined by **functional substitutability**: two values are distinguished if substituting one for the other perceptibly changes the flavor or color profile. Vinegar and lemon juice are separated (К3 and К4) because they differ in aroma and behavior during processing; berries and fruits are combined (К8) because they perform the same acidifying function and were historically interchangeable [4].

Finally, functional autonomy of the axes does not mean that one carrier cannot satisfy several axes (tomatoes—Ц3 and К5, sorrel—Ц4 and К6): the code records functions, not ingredients. Correlations among carriers are measurable features of the model. Beet' s multifunctionality might contribute to its modern

prototypical position, but does not by itself explain historical dominance: availability, agronomy, storage, prestige, standardization, and linguistic history are alternative causes.

[H] Functional matrix of components. The above can be represented as a "component → functions" matrix using a conventional three-point scale for contribution intensity:

Component	Color	Acid	Sweetness	Earthiness	Structure/body
Table beet	+++	+	+++	+++	++
Tomatoes	+++	++	++	–	++
Sorrel	+ (green)	+++	–	–	+
Kvass (bread/beet)	–	+++	+	+	+
Cabbage (including sauerkraut)	–	+	+	–	+++
Carrot	+	–	++	–	++

[H] The matrix expresses a hypothesis of **functional redundancy**: multiple ingredients may contribute to a function, and one ingredient may contribute to several functions. Expert-assigned symbols do not establish that replacing an ingredient preserves either categorical identity or the sensory profile. Substitution contrasts must test this. Until then, beet may be described as multifunctional but not as a demonstrably "optimal" or interchangeable carrier.

Status of the matrix. The values shown are expert estimates (on a conventional three-point scale), not measurements: the matrix is a hypothesis about the distribution of functions and must be tested. After the experimental series (Section 7), it should be recalculated from data: color by pigment concentration and CIELAB coordinates; acid by pH/TA and acid profile; sweetness by sugar content and sensory assessment; earthiness by geosmin (GC–MS). The three-point scale is used before calibration only as a visual summary and does not enter model calculations.

4.3. Formal type code

The five-dimensional classification allows any borscht to be represented by a compact **type code** Б = (Ц, К, Б, Т, С). Coordinate **Ц** of the code records the **source of pigment** (beet / tomatoes / absent)—in the terminology of Section 8, this is $\mathbf{Ц}^{2}$, whereas $\mathbf{Ц}^{1}$ (observed dish color, CIELAB) is an axis of the ИБ index. Superscripts are introduced to distinguish the origin of color from its measured magnitude and are used consistently below (see the notation note in Section 8). The code allows composite coordinate values where a variant uses multiple carriers of the same function (for example, К3+К5—vinegar and tomatoes simultaneously). Examples:

Variant	Type code
Classic beet borscht (meat broth, vinegar)	Ц1·К3·Б1·Т1·С1
Molokhovets' s "Little Russian borscht" (with kvass) [9]	Ц1·К1·Б1·Т1·С1
Molokhovets' s "Borscht from baked beet with wine" [9]	Ц1·К3·Б1·Т2·С1
Meatless Ashkenazi borscht [14]	Ц1·К4·Б4·Т1·С1
Polish *barszcz czysty* (clear, with *uszka*) [1]	Ц1·К1·Б3·Т4·С5
Cold Lithuanian *šaltibarščiai*	Ц1·К7·Б5·Т4·С2
Green (sorrel) borscht	Ц4·К6·Б1·Т0·С1
Luosong tang (Shanghai) [17]	Ц3·К5·Б1·Т0·С1
White *barszcz* on wheat flour sourdough with meat broth	Ц0·К9-пш.·Б1·Т0·С2

Variant	Type code
Barszcz biały na króliku po tokarsku (rabbit broth, vinegar, sour cream) [53]	Ц0·К3·Б1·Т0·С2
Borscht without fried vegetable base (Soviet recipes of the 1940s–1950s; stewing + beet infusion)	Ц1·К3·Б1·Т5·С1
Village borscht with beans and lard (modern family tradition [37])	Ц1·(К3+К5)·Б1·Т1·С3
Family variant (brisket, apple-cider vinegar + lemon, bell pepper, garlic [38])	Ц1·(К3+К4)·Б1·Т1·С3
Moscow borscht (smoked meats: ham, sausages; often without potato) [36]	Ц1·(К3+К5)·Б1·Т1·С2
Naval borscht (beef brisket + smoked meats, diced vegetables) [36]	Ц1·К3·Б1·Т1·С1
Poltava / Chernihiv borscht (duck/goose broth, sour apples or prunes, dumplings)	Ц1·К8·Б1·Т1·С3
Lenten monastic borscht (mushroom broth, beans, prunes)	Ц1·(К3+К8)·Б3·Т1·С3
Cold beet soup with kvass [36]	Ц1·К1·Б4·Т4·С2

Rows [37] and [38] are illustrative contemporary samples of living practice (primary documents of tradition; see the source-critical note in Section 2); they are included to demonstrate coverage of the code, not as historical standards.

4.4. Technological modifiers and serving ritual

Outside the five axes lies a layer of **technological modifiers**—techniques that do not constitute independent axes but alter texture and aroma within a single code: flour sauté (density and "silkiness" of the broth), geometry of vegetable cutting (the Naval standard of regular cubes [36]), a finishing paste of ground lard with garlic and herbs (independently documented in [37] and in generalized recipe practice), and finishing garlic [38]. **Serving ritual** is distinguished separately as an element of dish identity: *pampushky* with garlic sauce; rye (Borodinsky) bread, including bread rubbed with garlic or served with lard; smetana; fresh herbs; lard/schmalz; hot pepper. The composition of the accompaniment is not semantically accidental: starchy bread and *pampushky* form a neutral counterpoint to the sour-sweet axis, lard and garlic provide fatty and aromatic accents, while smetana acts as a final regulator of perceived acidity (the masking mechanism in the classification of the paired study [45, Section 4.5]). Crucially, this layer lies **outside** the structural code and outside axis T of the borscht-ness index (Section 8): technology is an internal property of the cooking process, whereas serving is an external cultural attribute appearing after that process. In model terms, serving ritual forms a separate layer of cultural modifiers (M): it affects perception and status of the dish but not its structural borscht-ness. This distinction also resolves heterogeneity in axis T: cold borscht variants differ from hot ones not by "different serving within technology," but by base and treatment type (Б5, Т4), with serving ritual remaining a common modifier М.

4.5. Similarity metric among varieties

The type code maps borscht recipes into a finite-dimensional discrete space. The simplest baseline distance between types is the count of mismatched coordinates (Hamming distance):

$\mathbf{d_H(Б_i, Б_j) = \Sigma_k\, I(Б_{ik} \neq Б_{jk}),\ 0 \leq d_H \leq 5}$, where *I* indicates a mismatch.

Examples: d(classic, Little Russian) = 1 (only acid source differs); d(classic, *luosong tang*) = 3 (color, acidity, and processing); d(classic, green) = 3. For the explicitly specified wheat-sourdough white *barszcz* with meat broth in the table, d(green, white) = 3 (Ц, К, and С differ).

Composite values and missing data. For a composite coordinate use Jaccard distance $\mathbf{d_k = 1 - |A \cap B| / |A \cup B|}$. If some coordinates are missing, report the normalized distance $\mathbf{\bar{d} = \Sigma d_k / m}$, where *m* is the number of comparable coordinates; this must not be directly compared to the unnormalized d_H. Show a sensitivity interval when coding is ambiguous. These rules extend the simple Hamming measure into a mixed distance, warranting separate notation.

Limitations and development. The baseline does not distinguish the importance of different coordinates. A possible extension is a weighted distance $\mathbf{d_w = \Sigma w_k d_k}$. Weights must not automatically be inherited from a membership classifier: predicting category decisions and describing similarity are different objectives. Euclidean distance on continuous measurements is meaningful only following prespecified scaling and checks for correlation; CIELAB coordinates, pH, and titratable acidity otherwise have incommensurable units. Before validation, d_H is a transparent baseline, not a lower bound on "true" similarity.

Status of Hamming distance —explicit baseline. Unweighted Hamming distance occupies the position of a **baseline** in the metric hierarchy: it is the simplest reasonable metric against which one assesses whether added complexity provides a real gain. Development proceeds along two axes simultaneously: weighting (w_j from BI calibration) and typing of elementwise distances. The code coordinates are of different types, and for mixed data Gower distance is a natural candidate; a typed sum remains an alternative, $\mathbf{d_f(Б_i, Б_j) = \Sigma_j\, w_j \cdot d_j(Б_{ij}, Б_{jj})}$, where for nominal coordinates (acid source К, garnish composition С), d_j is a binary mismatch or Jaccard distance for composites; for nominal coordinates including base type Б and processing method Т, it is a nominal match/mismatch metric; and for coordinate Ц when moving to measurements, it is distance in CIELAB space (ΔE between observed colors, axis $Ц^1$ of Section 8), rather than mismatch of pigment-source codes ($Ц^2$). The criterion for accepting the more complex metric is superiority over the Hamming baseline in predicting sensory and identification similarity of samples (Experiment 3): if the typed weighted metric does not predict panel responses better than d, the added complexity is rejected.

After corpus coding and external validation, the metric may help comparative analysis. **No threshold $\mathbf{d \le 2}$ is stipulated in advance:** without the distance distribution and its relation to independent judgments, such a threshold would be arbitrary. A metric formalizes differences; it does not by itself convert cultural arguments about membership into an objective measurement.

The type code and BI (Section 8) have different provisional purposes: the code describes recipes using selected coordinates, while BI is a candidate measure of similarity to a prototype. Neither establishes that a particular dish is borscht before validation.

The intersections of the axes generate dozens of stable configurations, consistent with the historical evidence: the term *barszcz* served as a generic designation for an entire family of sour soups made from very different raw materials [4]; dictionary fixation of the beet variant as the norm dates only to the beginning of the nineteenth century [5]; and cookbooks from the second half of the eighteenth century [7] and throughout the nineteenth century [9] already contained numerous stable variants of the dish.

---

5. Cultivar Types and Cultivated Forms of Beet as an Experimental Variable

All cultivated forms discussed belong to the single biological species *Beta vulgaris* L. Thus the variable is referred to as **cultivar type or raw-material type**, not "beet species." Differences in composition make cultivar type a multifactorial experimental variable.

5.1. Table beet

[D] The baseline variant. It is characterized by a high concentration of betacyanins: in dark-red (burgundy) cultivars, betalain content averages 141.85 mg/100 g fresh weight (range 64.5–218.8 mg/100 g), whereas yellow cultivars contain only about 24% of this level [22]. The principal pigments of burgundy cultivars are

betanin (59%) and isobetanin (23%) [22]. Table beet provides saturated color, moderate sweetness, and a pronounced earthy note (with cultivar-dependent variability in geosmin [31]).

5.2. Fodder beet

[T] Large roots with higher water content, lower sweetness, and lower pigment density. The research question is: how does borscht change when table beet is replaced by fodder beet? Expected effects include a paler color (lower betacyanin concentration per unit mass), the need to intensify acidic and sweet components, and a longer heat-treatment time—which in turn accelerates thermal degradation of pigment [24] and may produce a "rusty" hue.

5.3. Sugar beet

[D] In the sugar-beet samples studied, sucrose concentration depended on cultivar and storage and reached approximately 16–25 g/100 g fresh weight [28], [29]; this is not a universal specification for every root. **[T]** Replacing table beet with sugar beet is likely to increase sweetness, but the acid adjustment required need not be proportional: mixture perception is nonlinear and depends on salt, fat, temperature, and buffering capacity. This is a measurable prediction for Experiment 1.

5.4. Yellow cultivars of table beet

[D] A contrasting case: the pigment profile shifts from betacyanins toward betaxanthins (yellow-orange range); in yellow cultivars, vulgaxanthin IV dominates, accounting for 80% of betaxanthins [22]. **[H]** Borscht made with yellow beet is a natural experiment in replacing the pigment class: the dish preserves "beet" sweetness and texture but loses its red color, allowing the significance of color for identification as borscht to be tested.

5.5. Beet greens

[D] Young beet leaves are a historically early component ("borscht from beet tops"). Contemporary data show that *B. vulgaris* leaves contain significant quantities of betaxanthins (13.4–20.4 mg/kg fresh weight depending on cultivar) [32], and that in aggregate chemical profile, antioxidant activity, and antimicrobial activity the leaves exceed the corresponding roots [33]. **[D → T]** At the same time, most root pigments are concentrated in the peel [22]—an important technological consequence, because peeling beet reduces both pigmentation and geosmin content, which is likewise concentrated in the peel [30].

---

6. Functional Substitutes for Beet

[H] The central idea is to search not for "another beet," but for plants that perform **the same function** in the system (color, acidity, sweetness, earthiness).

6.1. Swiss chard (leaf beet, *Beta vulgaris* subsp. *cicla*)

[D] The closest relative of table beet; its leaves and petioles are eaten. Chard leaves contain pigments of **both betalain classes**—betacyanins (betanin, isobetanin) and betaxanthins [33], [34], with total betaxanthin content in chard leaves (up to 107 mg/kg fresh weight) substantially higher than in leaves of root-beet cultivars [32]. Petioles of colored cultivars can impart a pink-red tone to broth. **[D → T]** Swiss chard is the only substitute that preserves "beet chemistry" in the strict sense.

6.2. Sorrel (*Rumex acetosa*)

[D] Sorrel does not produce red color but creates characteristic acidity—the basis of green borscht. In the leaves studied, total oxalate content ranged from 273 to 954 mg/100 g fresh weight [27], depending on sample and processing. Adding a calcium source may reduce the soluble oxalate fraction [27]. **[H]** The established name "green borscht" shows that red pigment is not universally necessary for historical–lexical affiliation. It does not establish that acidity is sensorially more fundamental than all other features.

6.3. Tomatoes

[D → T] Tomatoes functionally replace part of beet's role on three axes at once: they provide red color (lycopene), acidity (citric and malic acids), and sweetness. In a number of regional practices, a sautéed tomato base completely or partially displaces beet. Tomatoes form a natural "bridge" between beet and beet-free borscht.

[D → T] *Luosong tang* is documented as a Chinese adaptation of "Russian soup" associated with émigré cuisine; in many variants tomatoes rather than beet provide its redness [17]. However, the name "Russian soup" is not equivalent to self-identification as "borscht," and the explanation that substitution occurred exclusively because beet could not be grown in the climate is not supported by agronomic data in [17]. *Luosong tang* is therefore an important candidate for a genealogically related variant, not a proven case of preserved borscht identity.

6.4. Historical precedent: hogweed

[D] The name is associated with common hogweed (*Heracleum sphondylium*), whose fermented stems and leaves were used in making a sour product [1]–[4]. **[D → T]** The historical change in the word's referent demonstrates the flexibility of a culinary term. It is not controlled evidence for functional or sensory substitutability of ingredients.

---

7. Program of Experimental Testing

To test the theoretical propositions, a series of controlled-variable experiments is proposed. This section is a research program rather than a report of completed studies.

[H] Testable hypotheses of the model. The model developed in Sections 4 and 8 is formulated predictively: it specifies what should occur when components are changed under controlled conditions. Eight key hypotheses are proposed:

- **H1.** After pilot calibration of intervention intensity, a change in sensory acidity will have a larger effect on recognition probability than separately matched changes in other sensory properties. Matching means a prespecified shift on a normalized sensory scale or a fraction of the within-sample standard deviation, not equal ingredient mass. If calibration fails, effects will be analyzed as separate causal contrasts without ranking absolute magnitudes.
- **H2.** In a sensory-matched pair, omitting beet-derived material will not reduce identification beyond a prespecified practical-equivalence margin. This tests limited substitutability, not identity between dishes.
- **H3.** Changing observed color while preserving taste and aroma will have a smaller effect than disrupting sour–sweet balance.
- **H4.** Structural distance from the classical reference (d_w; Section 4.5) will correlate negatively with recognition probability.
- **H5.** Documentedly named peripheral forms may exhibit lower sensory similarity to the red-beet prototype. Variability in responses is an empirical outcome, not an obligatory attribute of peripheral forms.
- **H6 (secondary, cross-class).** An identically operationalized reduction in acidity will affect borscht and shchi recognition differently. A greater effect on borscht will be preregistered as a hypothesis, not deduced from the uncalibrated thresholds of the two authorial models [45].
- **H7.** Color visibility (ordinary versus masking illumination) and red-ingredient source will be crossed factorially with the observed colors matched by tolerable ΔE across L*a*b*, not just a*. A difference persisting when color is masked indicates taste, odor, or texture contributions of the carrier; it does not identify which channel without further manipulations.

- **H8.** Compensatory architecture will be tested by comparing a prespecified additive model with a model containing a limited set of interactions. Support requires reproducibly better held-out prediction, not one significant coefficient.

[H] Three distinct hypotheses. Physical structure, reported information, and actual recipe history must be separated:

1. **H_s, structural effect:** with the information context fixed, a controlled change in a sample' s physical profile changes not just sensory similarity but its categorization as borscht.
2. **H_c, contextual effect:** holding the sample fixed, information supplied about name or provenance changes categorization and/or typicality. This concerns information and expectations, not actual genealogy.
3. **H^g, historical–genealogical hypothesis:** documented borrowing, transformation, and naming practices explain historical–cultural affiliation. Actual genealogy cannot be randomized by telling a participant something; it requires source-critical comparison of real lineages with structurally convergent analogues that arose independently.

Blind and contextual tastings can estimate H_s and H_c and their interaction. They cannot by themselves confirm or refute H^g. "Categorical decision" and "prototype typicality" are retained as separate outcomes because context and structure may affect them differently.

General design requirements. Independent preparation counts, recipe realizations, and participant numbers must not be arbitrarily fixed at n = 5. Following a pilot, simulation-based power analysis will use a prespecified minimum meaningful effect and the actual mixed-model structure. The unit receiving a cooking intervention is an independently prepared batch from randomized raw materials. Ratings by participants within a batch are repeated observations, not independent replicates. Generalization beyond one recipe pair requires multiple independently selected recipes of each type; if only two recipes are used, inference must be explicitly limited to those stimuli. Concealed coding, balanced order randomization, recipe and temperature control, acceptable-deviation protocols, and recorded achieved values are necessary. Equal raw-material mass and equal marker content address different causal questions and require separate series.

Panel separation. A trained descriptive panel rates descriptor intensities and does not determine cultural membership; consumer categorical responses are collected separately [50], [51], [52]. Categorical recognition is conducted on a sample of tradition bearers with prespecified strata (for example, Russian, Ukrainian, Polish, Ashkenazi, Chinese) and prespecified experience criteria. Pooling these groups into a single "standard" without testing differences is not permissible. For repeated measurements, participants and cooking batches are modeled as crossed random effects; day or raw-material lot is introduced as a block or nested effect according to the actual design.

Ethics and safety. Before the study, approval under the applicable ethics procedure, informed consent, recording of allergens and dietary restrictions, safe temperatures, and safe handling of samples are required. Added flavoring agents are allowed only as food-safe ingredients at permitted concentrations following separate safety review; pure geosmin is not proposed for serving to participants by default.

Temperature as a covariate. Because a single serving temperature is impossible for borscht (cold variants exist), temperature is included in the statistical models as a covariate (an accompanying variable, an accounted-for factor), and all comparisons are made within temperature class. In the joint two-week cycle [45], hot shchi (65 ± 2 °C) and cold borscht (≈4 °C) are not directly compared; if cross-temperature conclusions are needed, a separate temperature-controlled subexperiment is planned.

Blinding and carryover effects. Color is a strong sensory cue that is difficult to blind. To estimate the contribution of the visual channel to identification, a control subseries is planned using opaque cups (or monochromatic lighting that masks coloration). Carryover between soup samples is important: between

tastings, panelists receive water and neutral bread with a fixed interval of at least 2 minutes; with many variants, the panel is divided into balanced incomplete blocks to limit fatigue.

Matrix of confounding variables. Each confounder in the causal scheme (Section 8.2) is paired with an explicit control measure:

Confounding variable	Mechanism of bias	Control measure
Serving temperature	changes perception of acidity, sweetness, and volatiles	temperature as covariate; comparisons within temperature class
Visual channel	red color creates an expectation of "borscht-ness"	subseries in opaque vessels / monochromatic lighting; test H7
Serving order, fatigue	contrast and adaptation effects	balanced randomization; incomplete blocks; pauses ≥ 2 min
Matrix (salt, fat, dry matter)	suppresses acidity and sweetness without changing acid composition	recipe standardization; Level Γ of Experiment 2 (normalization for NaCl and dry matter)
Batch / day	between-batch variation, common raw-material lot	blocking and random effects (1 | batch), (1 | day); batch count from power analysis
Taster phenotype	individual strength of taste suppression	random effect (1 | taster); repeated ratings of a subset of samples
Taster' s cultural experience	shifts identification without changing sensory properties	experience questionnaire; Experiment 0 as external calibration cross-section
Reported name / provenance	may alter a decision via knowledge, expectations, or framing without changing the sample	factorial assignment of neutrally worded context; comprehension check; distinct blind and informed groups

Pilot and main series. A pilot develops preparation procedures, selects descriptors, and estimates variance; pilot effects are not used as confirmatory findings. The main series is powered separately. Restaurant visitors may constitute a consumer sample, but neither replace the trained descriptive panel nor count as representative without a specified sampling process.

Statistical plan. The plan is specified before the main series. Continuous instrumental outcomes are analyzed by mixed models with variant as a fixed effect and lot/batch as blocks; distributions and transformations depend on residual diagnostics. Descriptive sensory scores use repeated-measures models. Binary categorization uses a logistic mixed model with prespecified main effects, cultural strata, and a limited interaction set. Participants and independent batches enter as random factors; justified random slopes are included for within-participant factors. With multiple independently selected recipe realizations, stimulus/recipe is also modeled hierarchically or as a random factor. Simplification of the random structure is allowed only under a prespecified rule if the model is not identifiable. Graded similarity and confidence are modeled separately as ordinal outcomes. H2 receives a specified equivalence bound; H8 is assessed by predictive performance on held-out batches and recipes. Multiple confirmatory outcomes and contrasts are listed in advance, with control of the familywise error rate. The protocol, code, raw de-identified data, and complete recipe specifications are published.

Mapping theoretical features to measurable indicators:

Theoretical feature	Measurable indicator
Redness	CIELAB a* [18]
Lightness	CIELAB L* [18]
Yellowness (yellow cultivars)	CIELAB b* [18]
Chemical acidity	pH; titratable acidity
Buffer capacity	volume of alkali required to reach a specified pH (method from [45])
Sensory acidity	perceived intensity (profiling method)
Sweetness (S_1)	sugar content; sensory rating
Earthiness (S_2)	geosmin (GC–MS); sensory rating
Participant categorical decision	binary response "would classify as borscht"; measured separately in blind and contextual tasks
Prototype typicality	scaled rating of similarity to typical borscht; does not replace category membership

Importantly, **chemical and sensory acidity are different quantities**: two products with the same pH may have different titratable acidity and different perceived sourness. Therefore axis K is measured with two indicators in parallel, and conclusions about the flavor role of acidity are based on the sensory rather than solely the instrumental channel. The distinction between chemical and sensory acidity scales is developed in detail in the paired study [45, Section 3.2] and is adopted here without repetition. Borscht, like shchi, is a buffered system (broth proteins, organic acids, potato starch), so buffer capacity is included among the measurements even where it is not the central variable.

Experiment 0. Preliminary survey on necessary features

Before tastings, a preregistered survey is conducted in several cultural strata. The size of each stratum is determined by power requirements for comparisons of prespecified features. Respondents answer separately: (a) which characteristics they consider normatively necessary; (b) which variants they call borscht in their own practice; and (c) how familiar they are with each name. These responses must not be conflated with recognition of tasted samples. Rankings provide an external description of participants' conceptions; they are not used to assign weights and then assess those same weights on the same data.

Experiment 1. Beet cultivar type as a variable

The recipe and technology are identical; only the raw-material cultivar type differs: table beet (burgundy cultivar) / fodder beet / sugar beet / yellow table beet.

Metrics: broth color in CIELAB coordinates (L, *a*, b*) [18]; pH of the finished dish; sensory evaluation (sweetness, acidity, earthiness, broth richness—profiling method, 10-point scales), including a **temporal perception profile** (sequence: acidity at the beginning of the sip → beet-meat sweetness in the middle → spicy finish) as a target descriptor of the classic profile.

[T/H] Hypotheses: (a) fodder beet will yield significantly lower a* values (less red broth); (b) sugar beet will require a higher dose of acidifier to maintain balance; (c) yellow beet will shift color along the b* axis without losing the "beet" flavor profile.

Methodological caveat: beet cultivar type is not a single chemical variable but a **multifactor intervention of raw-material type** (pigments, sugars, water, fiber, geosmin, and softening kinetics all change simultaneously). The experiment is therefore interpreted as a comparison of technological cultivar types, not as isolation of the pigment factor; isolating the latter requires separate standardization by betalain content.

Experiment 2. Acidity source as a variable (paired causal contrasts)

The design is not constructed as a Б→В→Г→А "ladder," because its steps would differ in several properties at once. Instead, each actual acidifier is evaluated with prespecified paired contrasts:

- **Actual product ↔ synthetic acid profile** reproducing the major HPLC-measured acids;
- **Acid mixture ↔ dominant acid**, to estimate the effect of composition at approximately equal overall acidity;
- **Unstandardized ↔ standardized matrix**, with NaCl, soluble solids, sugar, and color adjusted within defined tolerances.

pH and titratable acidity are two different characteristics. Both are brought as close as practicable to prespecified targets within tolerance, but must not be described as simultaneously "matched" if doing so requires adding base, sugar, or water; such interventions are recorded and included in interpretation. The primary confirmatory comparisons are within pairs; between-acidifier comparisons are secondary.

Measurements: pH and titratable acidity; color stability during storage (repeat CIELAB measurements at 24 and 48 hours at 4 °C, following betalain degradation methods [21]); and descriptive sensory profile **A_s = (I, D, P, R)** [45].

[T] Hypothesis: real fermented acidifiers differ from synthetically reconstructed acid profiles on particular sensory descriptors. No direction of preference is prescribed in advance: sauerkraut findings [26] do not justify predicting that borscht will receive "higher ratings," and preference and descriptive intensity are different outcomes.

Experiment 3. Borscht without beet (central test of the model)

The central test is organized around prespecified matched pairs rather than a large unbalanced set. The primary pair consists of a classic specimen and a completely beet-free variant matched for sweetness, pH, titratable acidity, salt, dry matter, texture, and **full L*ab* color** within prespecified tolerances. The earthy note is first measured as naturally present; any separate aroma manipulation is performed only with an approved food material following a safety pilot. Additional single-factor contrasts manipulate acidity, color, or technology. Swiss chard and beet greens are analyzed separately as closely related substitutes, not as strict "beet-free" evidence. Shchi and gazpacho are external negative controls; green and white borscht are documentedly named peripheral variants. All recipes and tolerance limits are fixed before data collection.

Two categorization tasks: (1) a blind sensory task, in which participants see only a sample code; (2) a contextual task, in a separate session, in which participants are given a name, origin, or recipe history. Only comparison of tasks permits estimation of the cultural-context contribution; blind tasting does not test genealogy by itself. Outcomes are binary decision, graded similarity, and confidence. Entropy H(p) describes group disagreement, not individual uncertainty: $p \approx 0.5$ may result from two highly confident camps. Entropy and mean confidence are therefore reported independently, without presuming an obligatory inverse relationship.

Non-circular calibration. Data are separated by recipe type and independent cooking batch, with final evaluation on an external sample of participants and recipes not used to select the axes. At least four models are compared: ingredient-only, sensory, technological, and combined. Documented affiliation and participant judgments are two different criteria; neither is treated as an unconditional "gold standard".

[H] Hypothesis: sensory recognition will be better predicted by a combination of flavor and technological features than by binary beet presence. The competing hypothesis is that beet taste-and-aroma cues remain dominant even after the principal axes are matched. *Luosong tang* motivates the question of cultural transformation but does not determine the correct answer [17].

Minimal factorial test of structure H_s and reported context H_c

The *barszcz biały–żur/żurek* contrast is a demanding case for distinguishing physical resemblance from naming decisions. It is not one universal standardized recipe pair. The Polish register describes *barszcz biały na króliku po tokarsku* as a creamy-white sour soup containing rabbit broth, vinegar, and sour cream [53], and mentions historical white borscht made with wheat-flour sourdough. Modern regional boundaries between *barszcz biały* and *żur* may depend on flour type, ingredients, or local norms [54]. Accordingly, specific regional recipes must be selected and documented before testing; findings cannot automatically apply to all dishes bearing the names.

The least expensive design is embedded in Experiment 3 as a factorial comparison of **physical profile P × reported context C**. In its primary version, one specified structural characteristic—such as the kind of flour sourdough or how ingredients are technologically integrated—is manipulated while pH, titratable acidity, salt, fat, temperature, and dry matter remain within prespecified tolerances. This is **not** interpreted as a manipulation of acidity K. If K itself is studied, pH and titratable acidity become intervention variables, not controlled constants, in a separate contrast. An undefined simultaneous shift of K/S/T is excluded.

Context information is independently randomized. Participants receive a neutrally phrased description of a documented recipe tradition, without using the answer-giving category label. Comprehension is checked. Directly false labels are permissible only under an approved deception-and-debriefing protocol. The same participant must not receive the same physical sample under two contexts. The design tests the impact of communicated information H_c through expectations or framing, not factual genealogy.

Two primary outcomes are modeled separately: **(1) a binary categorization decision; (2) prototype typicality on a scale**. For categorical responses, use a logistic mixed model:

logit P(decision "borscht") = $\beta_0 + \beta_p \cdot P + \beta_c \cdot C + \beta_{pc} \cdot P \cdot C$ + cultural-stratum interactions + random effects.

Here P is the physical contrast and C is the reported context. The minimum random structure includes participant and independent cooking-batch intercepts, with a participant-level random slope for P if physical contrasts are repeated within participants. Add a stimulus/recipe effect if multiple recipe realizations are sampled. Typicality receives a separate ordinal model. Prespecify meaningful-effect minima and equivalence regions. H_s is supported within the selected stimuli if, with C fixed, the physical contrast reproducibly changes the categorical decision beyond the specified minimum. H_c is supported if, with P fixed, the reported information produces a meaningful effect. A simple $p > 0.05$ does not prove an absence of effect.

Independent effects of P and C, or their interaction, would show that participants' decisions are sensitive to both channels. Results are initially limited to the recipe pair tested. Broader inference requires replication on several structurally similar yet historically unrelated pairs and on documentedly linked yet structurally dissimilar variants. **The test has not been performed.**

Separate future test of H^g. Actual genealogy is tested using a comparative source-critical design: a prespecified corpus of real documented lineages is compared with convergently similar dishes for which no common history has been established; historical links are coded independently of sensory features and contemporary panel responses. The test asks whether a documented lineage predicts stable use of the name beyond structural similarity, region, and language. This observational study is not presented as completed work and cannot be replaced by an experimental statement about provenance.

Venue and schedule

A professional kitchen permits standardized preparation, but the main series cannot be compressed into a single "borscht week": independent batches, sufficient preparations, separate panels, and repeat sessions imply a multiweek blocked design. A one-week restaurant program may serve as an ecological-feasibility pilot. The main schedule must follow the pilot and power calculation; raw-material lots are randomized across conditions rather than confounded with condition or day.

How to interpret negative results

A null or negative outcome does not necessarily refute the entire model; it identifies the particular link that failed. The following interpretations are prespecified:

Negative result	What it refutes	What it does NOT refute
A real fermented acidifier and a reconstructed acid profile are equivalent within the stated margin (Experiment 2)	a meaningful sensory contribution from additional metabolites in the tested conditions	differences in other matrices, doses, and storage conditions
Beet removal markedly lowers recognition despite retained K/S/T (H2)	functional substitution in that panel	historically documented adaptations such as *luosong tang* [17]; the issue concerns categorization, not chemistry
Disrupting axis Ц has a stronger effect than disrupting K (H1, H3)	the hypothesis that acidity is the strongest predictor	the multi-axis model itself (the weights, not the axes, are revised)
At equal a*, beet and tomato pigments differ in identification in the blinded subseries (H7)	a purely colorimetric understanding of axis Ц	axis Ц as such; the contribution of non-pigment correlates of the carrier is refined
No reproducible compensatory interactions are found (H8)	the nonlinear BI architecture, favoring an additive model	the candidate axes or their weights
No cross-class asymmetry with shchi appears (H6)	the paired-model asymmetry hypothesis	the within-class predictions of either model
Reported context has no effect within a prespecified equivalence interval	H_c for these phrasings, stimuli, and participants	factual historical relationships or other forms of context
With context fixed, physical profile changes typicality but has an effect equivalent to zero on categorical choice	sufficiency of H_s for categorization in these stimuli	a sensory prototype or usefulness of BI for typicality
With physical profile fixed, context has no meaningful effect but structure reliably changes categorization	H_c for that manipulation	H^g, which is not directly tested by this experiment

Traceability matrix: hypothesis → variable → experiment → falsifier

Claim	Variable(s)	Experiment	Falsifier
Acidity is the strongest predictor of identification (H1)	identification proportion after component removal	Experiment 3 (removal series)	removal of K has no stronger effect than removal of other axes
Beet is a substitutable carrier of functions (H2)	identification with compensated absence of beet	Experiment 3 (variants а–в)	a sharp decline in identification with K/S/T retained
Color is an optional axis (H3)	identification with Ц[1] disrupted	Experiment 3 (control д)	effect of disrupting Ц ≥ effect of disrupting K
Structural distance predicts recognition (H4)	d_f / d_w from the reference × identification proportion	Experiment 3	correlation is absent or positive

Claim	Variable(s)	Experiment	Falsifier
Peripheral variants have lower sensory similarity despite a documented name (H5)	blind similarity × contextual categorization	Experiments 0 and 3	context does not change responses and similarity does not differ
Threshold logic in borscht is asymmetric to the threshold-free shchi model (H6)	decline in identification after removing acidity in the two dishes	Experiment 3 (з) + Experiment 3 of study [45]	the decline is the same
Color and carrier source make separate contributions (H7)	visibility × source at an acceptable ΔE	Experiments 1–3	the predicted main effects or interaction are absent
BI architecture is compensatory (H8)	axis interactions in the identification model	Experiment 3	the additive model is no worse than the model with interactions
Physical structure has an independent contribution to categorical decision H_s	physical profile P × reported context C; decision and typicality separately	minimal factorial test in Experiment 3	P changes typicality, but its effect on the decision is equivalent to zero after fixing C
Reported provenance affects categorical decision H_c	the same physical sample under different neutral contexts	minimal factorial test in Experiment 3	the effect of C on the decision is equivalent to zero with a successful context-comprehension check
A documented historical lineage predicts stable use of the name H^g	real lineages versus convergent analogues; independent source-critical coding	future comparative corpus test	after accounting for structure, region, and language, genealogical coding provides no reproducible additional information
Historical evidence is consistent with the model	—(context)	—	see the table in Section 1.3: history does not prove structure

---

8. Theoretical Model: the Borscht-ness Index

[H] The working hypothesis is that sensory similarity to a prototype is better described by a combination of characteristics than by one ingredient. To test this, a candidate scoring function—the **borscht-ness index (BI; ИБ)**—is proposed. Its formula comprises six observed coordinates grouped into five conceptual blocks (the sweetness–earthiness block is divided into S_1 and S_2):

$$\mathbf{BI = w_1 \cdot O + w_2 \cdot K + w_{31} \cdot S_1 + w_{32} \cdot S_2 + w_4 \cdot T + w_5 \cdot Ц^1}$$

where:

- **O (base):** a rich liquid base containing vegetables;
- **K (acidity):** a pronounced acidic component, regardless of its origin;
- **S_1 (sweetness):** the sweet component of the root-vegetable flavor profile (beet, carrot, parsnip, and substitutes);
- **S_2 (earthiness):** an earthy background associated with geosmin. S_1 and S_2 deliberately enter the index as **separate additive terms** with separate weights. They differ chemically and sensorially: sugar beet

can have the highest S_1 while differing from table beet in S_2, and in the quantitative version of the model they are estimated separately (Section 7). Earlier revisions combined them as S = (S_1, S_2); the present notation makes the composite structure explicit;

- **T (technology):** characteristic operations internal to cooking, including vegetable sautéing/stewing, dressed-soup structure, and thermal integration. Serving rituals are excluded and treated as external cultural modifiers M (Section 4.4);
- **Ц[1] (observed color):** the red/burgundy color of the dish as a measured quantity (CIELAB, particularly a*; the most variable axis, absent in green and white borscht). Ц[1] differs fundamentally from **Ц[2]—the pigment source** (beet / tomatoes / absent), which is recorded by coordinate Ц of the type code (Section 4.2): two dishes may have the same Ц[1] but different Ц[2], and separating these quantities makes it possible to formulate H7 (Section 7). It is Ц[1] that enters BI—the model describes perceived structure, not origin;
- **w_1, w_2, w_{31}, w_{32}, w_4, w_5:** nonnegative coefficients normalized so that $\Sigma w = 1$ if the index is to range from 0 to 1. Neither their order nor magnitude is prescribed as an empirical finding.

Notation note (alignment with the paired study). The pigment axis is denoted Ц[1], in accordance with the color axis of the type code (Section 4.2), whose coordinate records the pigment source (Ц[2]); the superscript separates measured color from its origin. An earlier version used the letter P, but in the acid-profile vector A_s = (I, D, P, R) of the paired study [45], P denotes temporal position of acidity. The collision has therefore been removed for joint reading of the two studies. The remaining letters are aligned semantically: O (base), K (acidity), and T (technology) are shared between ИБ and ИЩ [45]; sweetness axis S and pigment axis Ц are specific to borscht, while axis N (broth richness) is specific to the shchi model, where it is separated from O as an independent coordinate.

Preliminary anchors. Before instrumental calibration, features may be coded using three-point ordinal scales:

- O: 0 —water; 0.5 —weak stock; 1 —rich broth;
- K: 0 —acidic component absent; 0.5 —background acidity; 1 —pronounced acidity;
- S_1: 0 —sweetness absent; 0.5 —background sweetness; 1 —pronounced root-vegetable sweetness;
- S_2: 0 —earthy background absent; 0.5 —background earthiness; 1 —pronounced earthiness (geosmin note);
- T: 0 —different technology (including assembled okroshka-type structure); 0.5 —partial match; 1 —full set (stewing/sautéing of vegetables, dressed-soup structure, thermal integration);
- Ц[1]: 0 —red color absent; 0.5 —pink or orange tone; 1 —saturated ruby color (in colorimetry, normalized a*).

Status of the model. BI is a hypothetical scoring function, not a measurement instrument. The values 0, 0.5 and 1 on ordinal scales have not been shown to be equally spaced. Their use in a weighted sum is thus permissible only as a transparent expert prototype for simulations, not as an empirical finding. Previously suggested weights (0.2, 0.3, 0.15, 0.10, 0.15, 0.1), filters $K \geq 0.5$ and $S_1 \geq 0.5$, and threshold $BI \geq 0.6$ have been removed as classification rules: none were data-derived. After collecting a recipe corpus and experimental data, additive, nonlinear, and simpler baseline models will be compared, with calibration and evaluation on separate samples. If a single index offers no improvement in external prediction over simpler baselines, it should be abandoned.

Collinearity of axes. Axes correlate through multifunctional ingredients; individual regression coefficients may therefore be unstable and must not automatically receive a causal interpretation. Diagnostics include the correlation matrix, condition indices, and coefficient stability under resampling; regularization must be selected within the training data. Factor analysis is not an automatic solution: latent factors must be interpretable and reproducible.

Mapping the type code onto the index. The type code Б = (Ц, К, Б, Т, С) from Section 4.3 and the ИБ index are tools with different functions; their relationship is made explicit to avoid double-counting the same properties:

Code coordinate	Index axis	Nature of mapping
Ц (color source, Ц1–Ц4/Ц0)	$Ц^1$ (observed color)	not identity: the code records *origin* of pigment ($Ц^2$), the index records *measured* color; relation tested by H7
К (acidity source, К1–К9)	К (acidity)	the source determines acid profile С, but axis К measures *magnitude* of the acidic component (sensory + pH/TA), not its origin
Б (base, Б1–Б5)	О (base)	direct mapping: base type determines position on the "water → rich broth" scale
Т (beet treatment, Т0–Т5)	Т (technology)	partial: axis Т is broader, including the dressed-soup structure and thermal integration of all vegetables, not only beet treatment
С (garnish composition, С1–С5)	—	not included in the current formula; its incremental predictive value remains to be tested

The table makes the division of functions explicit: the type code is a preliminary taxonomic tool for describing recipe variants, whereas the index is a candidate measure of similarity to a selected reference variant. Neither determines historical–cultural affiliation or the correct name of a dish before validation. Origins of features ($Ц^2$, acidity source) remain in the code, while their perceived consequences ($Ц^1$, К) enter the index.

Before empirical calibration, BI does not determine class membership. The model's central testable proposition is:

> ***[H] For sensory similarity to the beet-based prototype, some functions of beet may be reproduced by other ingredients; the limits of substitutability are unknown.*** *Sources already show that red table beet is not required in all historically named borschts, but do not establish sensory equivalence of replacements.*

[H] The selected axes can describe many known variants retrospectively, but covering those variants is not predictive confirmation: they helped shape the axes. Prospectively held-out recipes and difficult negative controls are needed.

8.1. Class boundaries: core, periphery, and falsifiability

A candidate rather than established assignment procedure. The hypothesized sour–sweet core is tested directly. Until then, K and S_1 are not declared necessary filters, and BI = 0.6 is not used as a boundary. At least three outcomes are possible: (a) a stable threshold; (b) graded membership without a threshold; (c) multiple culturally specific prototypes. External prediction and stability across groups, rather than the convenience of symmetry with the shchi and okroshka models, determine the choice.

Candidate principle for distinguishing adjacent classes. "A thermally integrated dressed soup with a sour–sweet axis" is a testable rule, not a definition made true by convention. Preliminary contrasts are:

- **Shchi:** a candidate contrast with a different vegetable and technological structure; differences in sweetness and acidity are measured rather than imposed by a threshold.

- **Rassolnik:** a candidate acidic control for which the model predicts a lower sweet–earthy profile; this must be verified for specific recipes.
- **Solyanka:** a candidate control dominated by salty–smoky flavors and with a different hypothesized technological structure.
- **Botvinya, svekolnik (beet soup), and beet-based okroshka:** tests of whether assembly method and thermal integration really add information beyond taste and color. They cannot be excluded a priori on the basis of T, since that would make the definitional test circular; actual recipes are coded before categorical responses are obtained.

Core and periphery. White *barszcz*, clear *barszcz czysty*, and green borscht demonstrate that the named family is broader than the red-beet prototype. Their positions cannot be deduced in advance from BI or declared necessarily controversial: documented usage, blind sensory similarity, and contextual categorization are examined separately. For white *barszcz*, the regional meanings of *barszcz biały* and *żur/żurek* must be distinguished; coincidence or convergence of the names does not in itself establish a common technological genealogy.

Two levels of the model: structural similarity and historical–cultural affiliation. The foregoing requires an explicit terminological distinction between two concepts investigated by different methods:

1. **Structural similarity** is a candidate continuous characteristic of correspondence to the sensory and technological features of one or several prototypes. It becomes measurable only after validation of the scales and an external criterion; until then BI is a working hypothesis.
2. **Historical–cultural affiliation** consists of separately reported evidence of a documented name, a possible genealogical connection, and recognition within a particular tradition. This is not necessarily a binary social fact or one shared across all groups; having a cognate name in itself does not prove a common line of descent.

The second level is operationalized through three related but not independent indicators: (a) self-designation; (b) documented genealogy; and (c) recognizability and contextual categorization. Divergences between them are reported rather than automatically collapsed into a single score. This distinction between levels does not depend on a threshold and applies to any model in which physical similarity does not exhaust a social category.

The working framework is as follows: **The cognate names *борщ/barszcz* have historically been applied to a changing set of dishes; recipe continuity is documented for some lineages, but a unified genealogy of the whole set has not been established. Candidate structural parameters may measure sensory and technological similarity to one or more reference variants, but they do not replace the history of name usage.** Empirical research must determine whether contemporary judgments form a single core, several group-specific prototypes, or a network of similarities without one center.

Structure and genealogy: clarification of the model's scope. A structural criterion by itself may bring *luosong tang* close to convergently similar dishes. Genealogy is assessed not by the taste of gazpacho, but by comparing blind and contextual categorization together with historical source criticism. *Luosong tang* has a documented connection to "Russian soup" [17], but stronger historical sources are needed to establish the degree and type of its connection to specific branches of borscht.

Prototype and family resemblance: a hybrid framework. The model compares but does not conflate E. Rosch's prototype categorization [49] with L. Wittgenstein's family resemblance [39]. The former motivates graded sensory similarity, the latter a network of overlapping characteristics. The data must determine whether there is a single central prototype; one is not postulated as fact.

Falsifiability criterion. "Tradition bearers" are defined before participant recruitment using frequency of consumption, cooking experience, family or regional connection, and language used for naming. The

single-prototype hypothesis is rejected if the response structure consistently requires multiple group-specific models or if the prespecified axes fail to predict an external sample better than simple alternatives. The sour–sweet-core hypothesis is rejected if dishes outside this axis are systematically recognized as borscht in a blind task or if removing this axis does not produce the expected effect.

8.2. Causal scheme and confounding variables

For the experimental contrasts in Section 7 to receive a causal interpretation, an explicit causal scheme is specified (symmetrical with the scheme in the paired study [45]):

The initial structural hypothesis specifies the following links: raw materials and technology jointly shape the chemical state and physical matrix; these determine perceived taste, smell, texture, and color; these signals, together with participants' cultural experience, influence blind categorical decisions. In the contextual task, information about the name and provenance has an additional effect. Axis T is not purely sensory and is assessed from the preparation protocol rather than tasting alone.

The historical–genealogical hypothesis states that actual lines of borrowing and naming practices jointly shape recipe conventions and cultural affiliation, while the observed association between sensory profile and name may be a common consequence of both. The contextual hypothesis H_c differs: information reported to a participant can affect a decision through expectations, knowledge, or cues, independently of whether the genealogy is true. Thus the experiment contrasts the directions **physical profile → decision** and **reported context → decision**, whereas **actual history → {name, recipe}** is assessed by a separate source-critical design. These mechanisms are not mutually exclusive.

Color is tested through the visibility factor; cultural context through comparison of blind and informed tasks. Salt, fat, dry matter, temperature, raw-material lot, serving order, and participants' experience are treated as potential causes or modifiers, not automatically as "covariates" whose inclusion guarantees causal identification.

8.3. The model within the trilogy: three configurations of category

[H] The borscht-ness index forms a methodological trilogy with the ИЩ [45] and ИСТО [46] models; the models are not reducible to one another:

Parameter	ИЩ (shchi) [45]	ИБ (borscht)	ИСТО (okroshka) [46]
Candidate prototype feature	technology (slow stewing), vegetable mass	flavor balance (К, S_1)	physical parameters (Х, Н)
Candidate filter	absent	sour–sweet; no numerical threshold established	physical; status according to [46]
Core threshold	absent	not established	a priori in [46], requiring data
Acidity	optional axis; weight unknown until calibration [45]	candidate strong predictor; necessity unestablished	variable axis with replaceable carrier (axis К + code О) [46]
Multifunctional carrier	sauerkraut (V, К, Т)	beet (Ц[1], S_1, S_2, Т)	kvass (О, К, Г)
Type code	Щ = (О, V, К, Т, N)	Б = (Ц, К, Б, Т, С)	Ок = (О, Х, Н, П, К)
Convergent analogue control	kapuśniak	gazpacho / *luosong tang*	tarator / *šaltibarščiai* / gazpacho

Note to the table. In the "multifunctional carrier" row for ИСТО, carbonation (Г) is listed: it is a modifier, not an index axis—kvass covers axes О and К and modifier Г, but does not cover axes Х, Н, П, З; the ИЩ and ИБ rows list axes only. Identically named letters in different models do not necessarily denote the same measurement variable: for example, axis О in ИЩ spans "water → rich broth," whereas in ИСТО it spans "neutral water → fermented acidic base." In joint reading they should be distinguished as О_щ, О_б, О_ок.

A unified metalanguage of features for the trilogy is the subject of a separate methodological study in the project.

The trilogy proposes different hypotheses: acidity is treated as an optional axis of unknown weight before calibration in shchi, as a candidate strong predictor in borscht, and as a variable axis with a replaceable carrier in okroshka. Compensatory architecture is proposed in each study [45], [46]. This comparison does not provide independent confirmation and may reflect how the author constructed the models. Cross-class tests are justified only after outcomes, manipulations, and samples have been harmonized; until then the table is a map of hypotheses, not a comparative result.

---

9. Discussion

The proposed approach shifts attention from a single recipe to the relationships among names, documentable continuity, technology, and sensory similarity. Historical evidence places reliable limits on overly narrow universal definitions: red table beet is not present in all named variants and was not the original referent of the word [4], [5], [7], [9]. The evidence supports lexical continuity and individual lines of recipe transformation, but does not demonstrate a unified genealogy of all included variants or automatically choose among a single functional structure, several cultural prototypes, and a network of local categories.

Diaspora trajectories provide natural cases of transformation but not independent causal tests. *Luosong tang* retains its association with "Russian soup" [17], while Ashkenazi variants adapted to religious requirements [14]. In both instances composition, naming, and social memory changed together. These cases motivate experiments but do not prove that identification proceeds specifically through the proposed structural features.

Chemical data make acidity a plausible multifunctional factor: it affects taste and may influence betalain stability; a reaction of geosmin with acid is known in chemical systems [30]. Yet neither the magnitude nor even the practical significance of these effects has been measured in borscht. "Acidity as the structural backbone" and "beet as a replaceable carrier" thus remain hypotheses competing with simpler explanations.

White borscht and żurek as a test of the limits of explanation. White borscht is documented under the name *barszcz*, but particular versions differ substantially: source [53] describes a vinegar-based soup on rabbit broth and also points to historical wheat-sourdough versions; the boundary with *żur/żurek* depends on flour, composition, and local convention [54]. The names therefore cannot be treated as two individually standardized recipes. A factorial experiment on a chosen pair can estimate structural H_s and contextual H_c effects, but cannot establish actual genealogy or be automatically generalized to all regional forms.

The strongest supported claim. The cited sources document historically changing uses of the cognate names *борщ/barszcz* for structurally heterogeneous dishes, including beet-free variants, together with individual lines of recipe and lexical continuity. Red table beet, red color, and a fixed recipe are therefore not universally necessary conditions for all attested uses of the name. A unified genealogy of the whole set has not been established. The red-beet variant appears repeatedly in the sources and serves as a reference specimen; whether it is the only cognitive prototype, or a cross-culturally universal one, remains hypothetical. The proposed axes may become measures of structural similarity, but it is not yet known how similarity, cultural experience, and reported context jointly shape categorical decisions.

Limitations: no original recipe, chemical, or sensory data; neither the H_s/H_c factorial test nor a separate H^g comparative test has been conducted; the literature review is nonsystematic; completeness of regional coverage is unknown; some historical claims rely on secondary sources and [43] lacks a verifiable pinpoint locator; transfer from extracts and juices to soups is limited; the coordinates are expert-selected and may reflect confirmation bias; no single prototype or single threshold is established; prospective cultural groups are heterogeneous; the index and metrics are unvalidated. The paired works [45], [46] are manuscripts by the same author and are not independent confirmation. The established finding concerns the heterogene-

ity of historical–lexical usage and individual documented lines; the causal mechanisms of contemporary categorical decisions and a unified genealogy remain unresolved.

---

10. Conclusions

1. **[D]** Historical and recipe sources document dishes named borscht that do not contain red table beet. Accordingly, "borscht = all and only soups with beet" is not a universal definition across periods and traditions.
2. **[D]** The strongest supported result is the documented historically changing use of cognate names *борщ/barszcz* for structurally heterogeneous dishes and the existence of individual lines of lexical and recipe continuity. A fixed recipe, red table beet, and red color are not universal requirements of every attested use; neither unified genealogy nor a single prototype has been established.
3. **[D → T]** Beet is a multifunctional ingredient contributing pigments, sugars, texture, and a geosmin note. This does not establish that these functions suffice for identity, are fully substitutable, or historically account for beet's dominance.
4. **[T/H]** Acidity is chemically and sensorially relevant, but its status as a structural backbone or the strongest predictor of recognition is unestablished. Evidence from extracts, juices, and geosmin reactions offers mechanistic plausibility, not observations on finished borscht.
5. **[D/H]** Documented variability is consistent with multiple mechanisms. The pair "white borscht–żurek" is not a ready-made structural counterexample, since both names cover varying recipes. It allows a local test of structural H_s and contextual H_c effects to be designed, but cannot replace source-critical testing of historical–genealogical H^g.
6. **[D → T]** Beet cultivar/type is a meaningful experimental variable because pigments, sugars, water, fiber, and aroma change together. Such an experiment consequently assesses a composite raw-material substitution, not the isolated effect of a single substance.
7. **[H]** The type code, functional matrix, metric, and BI are candidate tools to describe prototype similarity. Their axes, weights, distances, and boundaries must be tested against an independently assembled recipe corpus and an external sensory sample; they are not criteria of cultural membership.
8. **[H]** A minimal factorial test independently varies one prespecified physical contrast P and neutrally reported context C, and separately measures categorical decisions and typicality. It can test H_s and H_c only for selected stimuli; actual H^g requires a distinct comparative source-critical design. None of these tests has yet been performed.
9. **[H]** Comparison with the shchi and okroshka models remains a secondary project hypothesis. Symmetry among the three models does not count as confirmation and must not determine features or thresholds before data are obtained.

Use of AI tools

Large language models were used in the preparation of this manuscript for editing, translation, discussing hypotheses, and searching the literature. Interpretation and conclusions are those of the author.

References

1. Borscht // Encyclopædia Britannica. URL: https://www.britannica.com/topic/borscht (дата обращения: 02.08.2026).
2. Черных П. Я. Борщ // Историко-этимологический словарь современного русского языка: в 2 т. 3-е изд., стереотип. М.: Русский язык, 1999. Т. 1. С. 105.

3. Gerard J. The Herball, or Generall Historie of Plantes. London: John Norton, 1597.
4. Dembińska M. Food and Drink in Medieval Poland: Rediscovering a Cuisine of the Past / revised and adapted by W. W. Weaver. Philadelphia: University of Pennsylvania Press, 1999.
5. Bandtkie J. S. Słownik dokładny języka polskiego i niemieckiego: w 2 t. Wrocław: W. B. Korn, 1806.
6. Похлёбкин В. В. Национальные кухни наших народов. М.: Пищевая промышленность, 1978.
7. Друковцов С. В. Поваренныя записки. [М.]: Тип. Имп. Моск. ун-та, 1779 (одно из ранних известных автору печатных описаний борща в отечественной кулинарной литературе; абсолютный приоритет не устанавливается).
8. Smith A. K. Recipes for Russia: Food and Nationhood under the Tsars. DeKalb: Northern Illinois University Press, 2008.
9. Молоховец Е. И. Подарок молодым хозяйкам, или Средство к уменьшению расходов в домашнем хозяйстве. СПб., 1861 и последующие издания: «Борщ малороссийский», «Борщ польский», «Борщ из печёной свёклы с вином», «Борщ из сельдерея», «Борщ постный с ушками», «Борщ из карасей» и др. Нумерация рецептов различается по изданиям (например, в издании 1901 г. «Борщ малороссийский» —№ 49); состав борщевого раздела именно первого издания 1861 г. отдельно не сверен.
10. Книга о вкусной и здоровой пище / отв. ред. Е. Л. Худяков. М.; Л.: Пищепромиздат, 1939.
11. A Feast Fit for the Last Tsar // Victoria and Albert Museum. 2017. URL: https://www.vam.ac.uk/blog/museum-life/a-feast-fit-for-the-last-tsar (меню коронационного обеда Николая II, 26.05.1896; музейный № E.1100-1931).
12. Что ели и пили российские самодержцы на отдыхе в Крыму, и не только // Крымский журнал. 2019. URL: https://journalcrimea.ru/s-istinno-tsarskoj-prostotoj/ (научно-популярный источник; использован как свидетельство бытового уровня традиции, не как основание историко-кулинарных выводов)
13. Goldstein D. Russia, Carême, and the Culinary Arts // The Slavonic and East European Review. 1995. Vol. 73, № 4. P. 691–715.
14. A Brief History of Borshch // Smithsonian Institution. URL: https://www.si.edu/object/brief-history-borshch:posts_8a6457e3e2b44d772eece97ab0fd7094 (дата обращения: 02.08.2026).
15. Roden C. The Book of Jewish Food: An Odyssey from Samarkand to New York. New York: Alfred A. Knopf, 1996.
16. From Pickles to Brisket: Recipes from the Ashkenazi Kitchen // Jewish Food Society. URL: https://www.jewishfoodsociety.org/collections/ashkenazi-jewish-recipes (дата обращения: 02.08.2026).
17. Kho K. L. Luosong Soup: Too Chinese to be Borscht? // Red Cook. 2018. URL: https://redcook.net/2018/03/22/winte russian-soup-luosong-soup-borscht/
18. Comparison of Colour Measurement Methods in the Food Industry // Processes. 2025. Vol. 13, Iss. 5. P. 1268. DOI: 10.3390/pr13051268. URL: https://www.mdpi.com/2227-9717/13/5/1268
19. Betalains: A Narrative Review on Pharmacological Mechanisms Supporting the Nutraceutical Potential Towards Health Benefits // Foods. 2024. Vol. 13, Iss. 23. P. 3909. URL: https://www.mdpi.com/2304-8158/13/23/3909
20. Strack D., Vogt T., Schliemann W. Recent advances in betalain research // Phytochemistry. 2003. Vol. 62. P. 247–269 (цит. по [19], [21]).
21. Degradation kinetics of betalains in red beetroot juices throughout fermentation process and storage // International Journal of Food Science. 2024. URL: https://www.itjfs.com/index.php/ijfs/article/view/2758/1272

22. Characterization of Betalain Content and Antioxidant Activity Variation Dynamics in Table Beets (Beta vulgaris L.) with Differently Colored Roots // Agronomy. 2024. Vol. 14, Iss. 5. P. 999. URL: https://www.mdpi.com/2073-4395/14/5/999

23. pH-dependent stability of major betalains in the encapsulated beetroot extracts (Beta vulgaris L.) // Journal of Food Science. 2024. Vol. 89, Iss. 5. DOI: 10.1111/1750-3841.17046. URL: https://ift.onlinelibrary.wiley.com/doi/10.1111/1750-3841.17046

24. Biological Properties and Applications of Betalains // Molecules (PMC8123435). URL: https://pmc.ncbi.nlm.nih.gov/articles/PMC8123435/

25. Prieto-Santiago L. et al. Relationship between color and betalain content in different thermally treated beetroot products // Journal of Food Science and Technology. 2020. Vol. 57(9). P. 3305–3313 (PMC7374684). URL: https://europepmc.org/articles/pmc7374684

26. Optimisation of Lactobacillus fermentation conditions and its application in the fermentation of salt-free sauerkraut // Frontiers in Microbiology. 2024. DOI: 10.3389/fmicb.2024.1482163. URL: https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2024.1482163/full

27. Tuazon-Nartea J., Savage G. Investigation of Oxalate Levels in Sorrel Plant Parts and Sorrel-Based Products // Food and Nutrition Sciences. 2013. URL: https://pdfs.semanticscholar.org/b20d/474a774dae4f7736c9ea2

28. Fresh and Stored Sugar Beet Roots as a Source of Various Types of Mono- and Oligosaccharides // Molecules (PMC9415824). URL: https://pmc.ncbi.nlm.nih.gov/articles/PMC9415824/

29. Elevating sugar beet by-products into healthier, natural, and functional ingredients // Exploration of Foods and Foodomics. 2025. URL: https://www.explorationpub.com/Journals/eff/Article/101074

30. Liato V., Aïder M. Geosmin as a source of the earthy-musty smell in fruits, vegetables and water: Origins, impact on foods and water, and review of the removing techniques // Chemosphere. 2017. Vol. 181. P. 9–18. DOI: 10.1016/j.chemosphere.2017.04.039

31. Freidig A. K., Goldman I. L. Geosmin (2β,6α-dimethylbicyclo[4.4.0]decan-1β-ol) production associated with Beta vulgaris ssp. vulgaris is cultivar specific // Journal of Agricultural and Food Chemistry. 2014. Vol. 62(9). P. 2031–2036. DOI: 10.1021/jf4047336

32. Betaxanthin Profiling in Beta vulgaris Leaves and Gymnocalycium mihanovichii Grafted Cacti: A Comprehensive Study // Polish Journal of Food and Nutrition Sciences. 2023. URL: https://journal.pan.olsztyn.pl/Betaxanthin-Profiling-in-Beta-vulgaris-Leaves-and-Gymnocalycium-mihanovichii-Grafted,175032,0,2.html

33. Exploring the Biochemical Profile of Beta vulgaris L. (PMC11859049) // Plants / PMC. URL: https://pmc.ncbi.nlm.nih.gov/articles/PMC11859049/

34. Kugler F. et al. Studies on betaxanthin profiles of leaves of Swiss chard (Beta vulgaris L. subsp. cicla) —цит. по [32], [33].

35. Анфимова Н. А., Татарская Л. Л. Кулинария: учебник для нач. проф. образования; учеб. пособие для сред. проф. образования. 4-е изд., стер. М.: Академия, 2016 (классификация супов: по температуре подачи, жидкой основе, способу приготовления).

36. Сборник рецептур блюд и кулинарных изделий для предприятий общественного питания: Сборник технических нормативов. Ч. 1 / под ред. Ф. Л. Марчука. М.: Хлебпродинформ, 1996 (энумеративный перечень видов борща).

37. Клименко А. А. Украинский борщ бабули Зины: семейный рецепт деревенского борща. 2019 (первичный документ живой кулинарной традиции: финишная заправка из перетёртого сала с чесноком, фасоль в овощном составе, композитная кислотность «томатная паста + уксус»).

38. Семейный рецепт борща: устная традиция; личное сообщение, 2026 (грудинка для бульона, яблочный уксус с коррекцией кислотности лимонным соком, сахар по вкусу, болгарский перец, финишный чеснок, молодая капуста).

39. Витгенштейн Л. Философские исследования // Витгенштейн Л. Философские работы. Ч. 1. М.: Гнозис, 1994 (§§ 65–71: понятие семейного сходства).

40. Домострой (середина XVI века; наставление об устройстве огорода и запасах на год) / подг. текста, пер. и комм. В. В. Колесова. М.: Советская Россия, 1990.

41. Глазкова Е. А. «Борщ» в языке и культуре русского народа // Studia Rusycystyczne. Kielce: Uniwersytet Jana Kochanowskiego, 2021. Т. 29. S. 49–57. DOI: 10.25951/4792 (лексикографическая фиксация слова у В. И. Даля; корпусный анализ употреблений в НКРЯ; примеры из художественной литературы).

42. Borscht Belt // Diversity Style Guide. 2016. URL: https://www.diversitystyleguide.com/glossary/borscht-belt/; History // Catskills Borscht Belt Museum. URL: https://www.borschtbeltmuseum.org/history

43. Новгородские ямские книги. 1586–1631 гг. / изд. И. Я. Гурлянд. Ярославль: Тип. Губернского правления, 1900. Фрагмент устава огородникам дворцовых сёл («свекла на росолы на ставленые, боршъ и всякои огороднои овощъ») подтверждён по полному тексту издания (открытая электронная копия: archive.org, ид. libgen_00298658); страница уточняется по экземпляру издания. До этого источник используется только как вспомогательное свидетельство.

44. Мартин Груневег (отец Венцеслав): духовник Марины Мнишек. Записки о торговой поездке в Москву в 1584–1585 гг. / сост. А. Л. Хорошкевич; Ин-т славяноведения РАН, Ин-т рос. истории РАН. М.: Памятники исторической мысли, 2013. 384 с. С. 161. Одно из ранних известных автору упоминаний борща как готового блюда (Киев, октябрь 1584; раздел 1.2).

45. Корякин А. Н. К вопросу о формировании кислотно-вкусового профиля традиционных щей. Рукопись, 2026. (Методологическая пара настоящей работы: разложение кислотного профиля (химический блок C_abs/C_rel и сенсорный профиль A_s = (I, D, P, R)), различение химической и сенсорной шкал кислотности, механизмы управления воспринимаемой кислотностью, буферная ёмкость, модель «индекса щевости» (ИЩ).)

46. Корякин А. Н. Окрошка как многофакторная кулинарная система: модель структурно-сенсорной типичности и программа проверки категориальной идентичности. Исследовательская рукопись, редакция 1.0, 2026. (Третья работа тройки: индекс структурно-сенсорной типичности окрошки (ИСТО), код типа Ок = (О, Х, Н, П, К), кандидатный порог физической типичности X ≥ 0,5 и H ≥ 0,5 —не порог членства; раздел 8.3.)

47. Ahn Y.-Y., Ahnert S. E., Bagrow J. P., Barabási A.-L. Flavor network and the principles of food pairing // Scientific Reports. 2011. Vol. 1. Art. 196. DOI: 10.1038/srep00196.

48. Bellingeri M. et al. The recipe similarity network: a new algorithm to extract relevant information from cookbooks // Scientific Reports. 2025. Vol. 15. Art. 34380. DOI: 10.1038/s41598-025-17189-6.

49. Rosch E. Principles of categorization // Cognition and Categorization / ed. E. Rosch, B. B. Lloyd. Hillsdale, NJ: Lawrence Erlbaum Associates, 1978. P. 27–48.

50. ISO 8586:2023. Sensory analysis —Selection and training of sensory assessors.

51. ISO 13299:2016. Sensory analysis —Methodology —General guidance for establishing a sensory profile.

52. ISO 11136:2014. Sensory analysis —Methodology —General guidance for conducting hedonic tests with consumers in a controlled area.

53. Barszcz biały na króliku po tokarsku // Ministerstwo Rolnictwa i Rozwoju Wsi Rzeczypospolitej Polskiej: Lista Produktów Tradycyjnych. 25.10.2019. URL: https://www.gov.pl/web/rolnictwo/barszcz-bialy-na-kroliku-po-tokarsku (дата обращения: 20.09.2026).

54. Poland's Most Original Soup: Żur // Culture.pl. 19.12.2022. URL: https://culture.pl/en/article/polands-most-original-soup-zur (дата обращения: 20.09.2026; культурно-исторический обзор вариативности различения *żur* и *barszcz biały*).

Revision history

1.0 — 19 October 2026. First public revision.