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The Carbohydrate Matrix: An Exploration of Processed, Piquant Consumable Products

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ABSTRACT

Decades of research have been devoted to defining the essence of several consumer products. Many laboratories were set up to investigate the fundamental characteristics of cereals, often with conflicting results due to the highly speculated internal biases. This was overcome by the creation of the Cereal Grid, breaking down the necessary components of cereals into two dimensions. In the meantime, new research in the processed, piquant consumable product field has attempted to similarly synthesize the core features of snacks. One such hypothesis, Cheez et al. (2021), attempted a cheese flavor spectrum, highly biased against non-cheese related products. Therefore, a new description of complex carbohydrate products was necessary to avoid history repeating itself and the initialization of similar wars often referred to as The Snack Attacks, The Salty Struggle, or The Chip Confrontation. In this paper, we present the discovery of the Carbohydrate Matrix, a new standard model for the description of processed, piquant consumable products.

Keywords: carbohydrates; flavor; texture; flatness; chip; snack; consumables; Cereal Wars

1. WHAT IS A CHIP?

This investigation was initiated by a foundational definitional inquiry: what constitutes a "chip"? More precisely, the question of the categorical inclusion of Cheetos within the broader chip taxonomy, despite their apparent deviation from canonical chip characteristics such as structural rigidity conducive to scoopability, a flat or sliced morphology, and traditional corn-based fabrication. This apparent incongruity necessitated a systematic examination of snack food attributes, ultimately prompting the development of a structured classification framework.

Previous work has examined the flavor profiles of several snack-based consumables that resulted in much scorn and rebuke from the community (e.g. Cheetah et al., 2023) due to the personal affiliation of authors to corporate insiders. Past scandals in cereals (e.g. Crunch et al., 1972; Tiger et al. 1977; Snap & Crackle 1979; Pop 1980) led by familial relations to prominent cereal industry leaders ignited what was then known as the Cereal Wars. This conflict lasted two decades with each major brand staking their claim as the tastiest. This led to the seminal work of Di Graines et al. (1999) deciphering the "Cereal Grid", breaking down cereals into their most important features: sweetness and crunchiness.

In order to avoid a similar conflict in the vastly more important salty snack food industry, we set out to explore the major components of processed consumable products. In this paper, we formulate the newly minted "Carbohydrate Matrix", through which processed, piquant consumable products may be more rigorously evaluated and compared. In Section 2, we describe the key components of our proposed matrix. In Section 3, we described the key products and several key categories in the industry. In Section 4, we discuss additional considerations made in producing the matrix in order to head off any unnecessary backlash from industry. In Section 5, we present future exploratory dimensions of the piquant consumables industry, venturing beyond processed products. In Section 6, we summarize our conclusion.

2. PROPOSED MATRIX

In the modern paradigm of processed consumables, various corporations have attempted to mark their prod-

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uct as excelling the categories they define as most important. However, these studies are frequently riddled with inaccuracies and obvious biases. In Cheez et al. (2021), cheesiness was defined as the pinnacle of piquant consumable characteristics, completely biased against boldly flavored products, e.g. salt and vinegar chips. Similarly, in Dore & Itto (2020), crunchiness was borrowed from the Cereal Grid to quantify optimal chip quality with the astonishing omission of the Pringle. Here we present our Carbohydrate Matrix composed of the three fundamental parameters constituting processed bite-sized consumable products.

2.1. *Texture*

Piquant products have a wide variety of textures that are desired by a variety of consumers. From soft popcorns to stale pretzels, the feel of the product on first bite is frequently correlated with consumer satisfaction (Smith, Smith, and Smith, 1321). However, this feel is not directly correlated with crunchiness. While crunchiness was used to settle the Cereal Wars, we considered this as an oversimplification of the texture concept.

First, texture can change as consumers masticate these products. Initial crunchy bites can quickly change to mushy gruel in the mere seconds post-mastication. On the other hand, soft popcorns frequently contain hard kernel centers surprising unsuspecting eaters, sometimes resulting in fractured cusps and vertical root fractures. These unsuspecting events are severe hindrances on the material ability of consumers to continue purchasing processed consumables, particularly in the American market due to high costs on procedures the fees to which we cannot find data in European markets (surely a data keeping error). Lastly, the amount of crunch does not correlate with product satisfaction in any way, see Fig. 1, as tested on several product participants even though they rated "feel" as an important aspect of eating snacks.

To overcome these deficits, we arrived at the texture criterion that is not intended as a measure how much much the texture is liked, but instead a way to rank textures of salty snacks and accurately place them onto the Carbohydrate Matrix. The criterion is evaluated based on the initial hardness of the product after the first bite. A value of zero is represented by soft popcorns, e.g. Pirate's Booty, and a value of ten is represented by the pretzel stick, a classically hard snack, see Fig. 2.

2.2. *Flavor*

While Cheez et al. (2021) characterized a parameter as cheesiness, we reject this factor as it is too narrow and cannot be applied to the vast array of popular products. Instead, we propose the use of the flavor metric

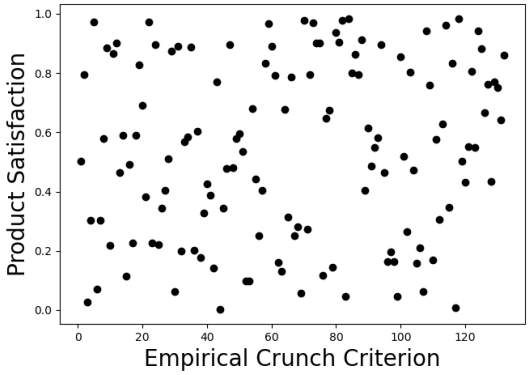

Figure 1. We tested several products based on the tensile strength of the product, given to 132 willing participants. We ranked product satisfaction (self-reported by participants) against the crunch criterion and see zero correlation, with an R squared value of 0.

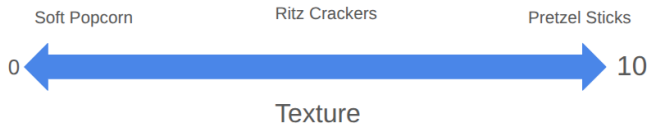

Figure 2. A one-dimensional representation of our texture profile with three examples.

that spans from bland to tasty that has the ability to encompass all delicious profiles of several snacks. We demonstrate the range of the flavor metric in Fig. 3. The low range of flavor profiles are typically bland, unseasoned chips that are intended for dipping, e.g. pita chips. On the high end of the flavor profile, highly seasoned rolled tortilla chips come with extreme concentration of spice, providing bold, sometimes overpowering flavors, particularly to the Scandinavian and American Midwest market (excluding major urban centers). Again, low or high flavor profiles are not a quality judgment or preference, but a quantitative approach to classifying processed products.

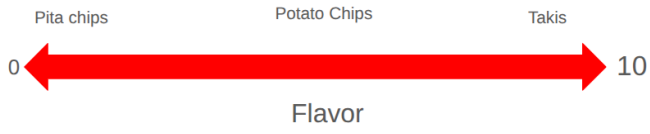

Figure 3. A one-dimensional representation of our flavor profile with three examples.

Importantly, similar products can include varying flavor profiles, none more important than the potato chip, often encompassing entire rows of shelves in grocery stores. In Fig. 4, we present the distribution of sev-

eral potato chip flavors onto the flavor dimension from regular to cheddar and sour cream. Other high values of flavor include the flaming hot variety of popular processed products.

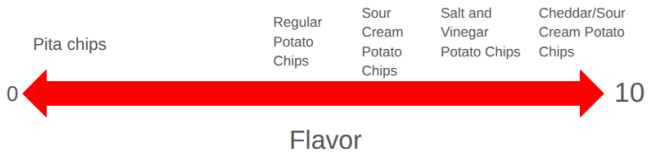

Figure 4. A one-dimensional representation of our flavor profile with several examples of different chip varieties ranked on our empirical flavor relation.

2.3. *Flatness*

Finally, the third dimension of the Carbohydrate Matrix is flatness. While several shapes and variety of structure could have been used in this description, we settled on flatness to optimize the ability to quantitatively describe the vast assortment of products. Roundness was another possible characteristic which we rejected as some objects can both be round and flat, e.g. bagel crisps. Additionally, a generalized "shape" parameter was not conducive to a quantitative assessment. Due to the prevalence of chips in the processed products variety, we decided to preference a flatness criterion as it allows for distinguishing between flat but rounded potato chips and nearly flat tortilla chips. All combined, these three metrics make the Carbohydrate Matrix, an empirically derived, quantitative analysis that encompasses the major features of all processed consumables.

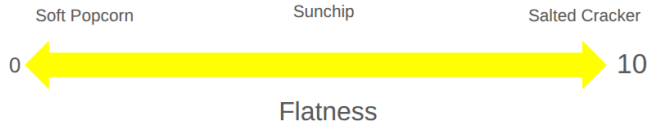

Figure 5. A one-dimensional representation of our flatness profile with three examples.

3. KEY PRODUCTS WITHIN THE MATRIX

The snack products represented within the proposed matrix may be broadly classified into four primary ingredient-based categories: wheat, corn, potato, and puff. Each category exhibits distinct compositional, textural, and flavor characteristics that inform its placement within the matrix.

3.1. *Wheat-Based Snacks*

Wheat-based snacks are typically produced from wheat flour and baked rather than fried. Relative to corn- and puff-based counterparts, this category demonstrates a markedly lower baseline flavor intensity, with seasoning often limited to sodium chloride. Notable exceptions include Cheez-Its and Goldfish crackers, in which the incorporation of baked cheese substantially enhances flavor complexity. The generally restrained flavor profile of wheat snacks is hypothesized to reflect their frequent consumption as vehicles for external accompaniments—most commonly dips such as hummus or buffalo dip—which contribute the majority of sensory impact within a combined bite. As such, wheat snacks appear to function less as standalone flavor agents and more as structural substrates within a broader snack ecosystem. Wheat-based snacks in the matrix include:

Table 1. The definitive guide to small consumable carbohydrate products.

Complex Carbohydrate	Texture	Flavor	Flatness
Pirate's Booty	0	4	0
Cheeto Puff	1	6	0
Funyun	3	6	1
Cheeto Classic	6	7	1
Takis	7	10	1
Doritos	6.5	8.5	9
Corn chip	6.5	4	9
Pita chip	9	0	8
Salted Cracker	6	1	10
Ritz Cracker	6	2.5	10
Bagel Crisp	10	4	9
Pretzel Crisp	9	3	9
Pretzel Stick	10	3	3
Veggie Straw	2	2	0
Veggie Chip	6	2	8
Potato Chip	5.5	5	6
Ruffles	6	6	6
Sunchips	7	4.5	4
Fritos	8	6.5	5
Cheez-It	5	7.5	9
Goldfish	6	5.5	7

NOTE—Each tested snack product is rated from 0-10 in three key diagnostics. Texture ranges from 0-10 with 0 being soft and 10 being hard. Flavor ranges from 0-10 with 0 being bland and 10 being very tasty. Flatness ranges from 0-10 with 0 have significant non-descript deviations from flat and 10 being very flat. We find that shape is an important factor that must be quantified in terms of flatness, anti-flatness, or roundness, choosing flatness as the optimal criterion.

Saltine crackers, Ritz crackers, bagel crisps, pretzel crisps, pretzel sticks, pita chips, Goldfish, and Cheez-its.

3.2. *Corn-Based Snacks*

Corn-based snacks are commonly manufactured from cornmeal, oil, and salt, and are produced through baking, frying, or a combination of both processes. These products typically rank high on the textural rigidity scale and are characterized by a distinct roasted corn aroma. Morphologically, corn snacks often exhibit curved or folded geometries, a feature that facilitates efficient dipping and load-bearing capacity. Beyond standalone consumption, corn snacks are frequently repurposed as garnishes in chili, soups, and salads. Flavor profiles within this category vary widely, ranging from the relatively restrained salt-forward profile of traditional tortilla chips to the highly seasoned and aggressively flavored extremes represented by products such as Doritos and Takis. Corn-based snacks in the matrix include: Takis, Doritos, tortilla chips, Sunchips, and Fritos.

3.3. *Potato-Based Snacks*

Potato-based snacks are derived from sliced or reconstituted potato and are typically deep-fried, baked, or air-fried. These snacks are generally thinner than their wheat- and corn-based counterparts, resulting in a distinct textural experience. The comparatively neutral intrinsic flavor of potato serves as an effective foundation for the application of bold seasoning blends, including barbecue, chili lime, and salt-and-vinegar formulations. Within the context of the matrix, potato chips most closely align with the colloquial and cultural archetype of the "standard" chip, a classification that the authors' findings broadly support. Potato-based snacks in the matrix include: Lays, Ruffles, and Terra's Root Vegetable Chips.

3.4. *Puff-Based Snacks*

Puff-based snacks are produced from corn, rice, legumes, or composite starches that are subjected to high heat and pressure, resulting in an expanded, lightweight, and aerated structure. In their unseasoned form, puffs exhibit relatively low flavor intensity; however, this structural neutrality renders them particularly effective as carriers for savory, spicy, and umami-forward flavor coatings. Similar to potato-based snacks, puff products derive much of their sensory appeal from post-processing seasoning rather than from the base substrate itself. Puff-based snacks in the matrix include: Pirate's Booty, Cheeto Puffs, Funyuns, Cheetos, and vegetable straws.

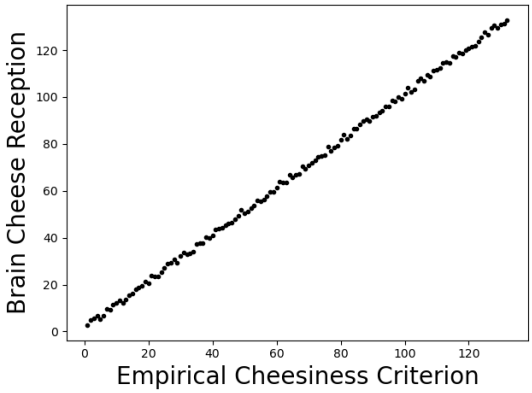

Figure 6. fMRI results showing the cheese criterion with an R squared value of 0.99. We directly demonstrate how our criterion correlates with brain reception of cheese flavor, although importantly not all flavor.

4. ADDITIONAL CONSIDERATIONS

4.1. *Margin of Error*

Methodological limitations were introduced by the authors' inability to procure and empirically evaluate every snack product represented within the proposed matrix. In such instances, classifications were informed by retrospective sensory recall, a reliance that may have introduced subjective bias and variability into preliminary rankings. Indeed, multiple assumptions derived from memory were subsequently challenged when products were evaluated under controlled, side-by-side conditions. Notably, Goldfish crackers were initially hypothesized to exhibit a lower textural rigidity than Cheetos; however, comparative testing demonstrated that both products possess a comparable crunch factor. These discrepancies underscore the importance of direct sensory assessment in future iterations of the matrix and highlight the provisional nature of classifications derived without contemporaneous testing. In the interest of scientific rigor, reproducibility, and snacks, the authors openly acknowledge that financial sponsorship, in-kind donations, or unmarked deliveries of assorted chips from the so-called "Big Chip" lobby would be enthusiastically accepted to facilitate more exhaustive, unbiased, and well-fed future research.

4.2. *Snack Neighborhood*

Owing to the first author's preference for visual and metaphor-driven cognitive frameworks, the carbohydrate matrix was initially conceptualized as a "neighborhood," in which the intersecting streets of a grid-organized suburb served as analogues for the x- and y-axes. This two-dimensional construct was originally arranged according to snack morphology and base ingre-

Figure 7. 2-D Snack Neighborhood.

dient composition, a relationship most clearly illustrated by the left-to-right progression from Lay's potato chips to Doritos, as seen in Fig. 7. As discourse surrounding the snack neighborhood evolved, it became evident that the conceptual model required an additional dimension to adequately capture the observed distinctions. Concurrently, the analytical focus was refined to the three primary determinants of snack classification seen in the matrix: texture, flavor, and flatness.

4.3. *Conceptions of Cheesiness*

Due to the controversial claims of Cheez et al. (2021), we considered a unique dimension of cheesiness. First, we discussed a dimension only related to concentration of cheese. This is defined as the concentration of casein, triglycerides, lactose, and calcium per average human bite. While this encapsulates the amount of cheesiness, it is unable to derive the full encapsulation of cheese reception within the cerebral cortex. This was unable to incorporate differences in dense mild cheddar cheeses against soft pepperjack varieties. To overcome this dilemma, we produced the full cheese flavor line shown in Fig. 6. This correlation shows fMRI brain reception of the cheesy portion of the cerebral cortex, demonstrating a claim relationship between how the brain reacts to cheesy flavoring and our new criterion. Importantly, not all flavoring is cheese based. This results in the inability to utilize cheesiness in the Carbohydrate Matrix which is thus infused into the Flavor dimension, see Sec. 2.2.

5. FUTURE EXPLORATORY DIMENSIONS

5.1. *Dips*

A particularly compelling avenue for future expansion of the carbohydrate matrix involves the formal incorporation of dips. Returning to the conceptual framework of the Snack Neighborhood, dips may be analogized as swimming pools—supplementary amenities that substantially enhance the livability and appeal of adjacent snack structures. Widely adopted dips that transcend foundational ingredient categories function as communal pools, broadly accessible across multiple snack "residences." By contrast, the archetypal Seven Layer Dip occupies a more dominant geographic role, analogous to a lake upon which the snack neighborhood itself might plausibly be situated. Beyond adding an additional analytical dimension, dips also appear to operate as connective mechanisms between otherwise incomparable snack categories. This phenomenon is exemplified by the tortilla chip, which maintains a near-exclusive association with dips, such as guacamole, salsa, and queso, due to its flavor profile and structural integrity, which allows it to withstand the increased density of guacamole,

moisture level of the salsa, and the weight of queso. The respective dairy and produce bases of these dips facilitate transitions—conceptualized here as alleyways within the neighborhood—to adjacent snack domains, including the cheeses, cured meats, vegetables, fruits, and nuts commonly found on a charcuterie board. In this way, dips not only enhance individual snack experiences, but also enable broader inter-snack mobility within the consumable landscape.

5.2. *Charcuterie*

In practice, charcuterie encompasses such a wide range of snack types and flavor combinations that it arguably warrants its own multidimensional matrix to adequately capture the sheer diversity of popular configurations. For the purposes of this paper, however, charcuterie offerings are considered strictly within the confines of the carbohydrate matrix. Snacks within the matrix that most frequently interface with charcuterie are largely confined to the wheat-snack region. This distribution is attributed to the generally high load-bearing capacity of wheat-based snacks, as well as their relatively low flavor intensity, which together provide an ideal foundation upon which to construct the optimal "one bite" from a charcuterie board.

The overarching objective of charcuterie is to produce a spread that enables near-endless combinations, offering a balanced flavor interplay of savory, sweet, salty, funky, and sour elements, while also encompassing a broad spectrum of textural resistance and bite complexity. Initial categorizations and functional purposes of common components are as follows. Owing to its extensive range of varieties and flavor profiles, cheese contributes most consistently through texture, frequently acting as a unifying binder that harmonizes disparate elements within a single bite. Cured meats primarily contribute salinity, a critical component for cutting richness and stimulating the palate. Vegetables such as carrots and cucumbers are commonly served julienned, though round slices remain popular; depending on preparation, they may offer freshness when raw or funk when pickled. Acidic pickled vegetables serve a function similar to that of cured meats by refreshing the palate and preventing sensory fatigue. Raw vegetables offer a crisp, fresh counterpoint to richer components and additionally function as effective vehicles for dips. Fruits occupy a similar role in terms of presentation versatility, but contribute sweetness when raw or savoriness when dried. A further fruit-based preparation, jam, is also widely accepted and frequently deployed on the charcuterie board. Nuts constitute the final primary component of a charcuterie board. From a flavor perspective, their contribution is modest, typically adding a controlled degree of salinity. Their principal functional role, however, lies in introducing textural contrast and concentrated flavor depth, both of which enhance bite complexity and contribute to overall sensory balance within the assembled spread.

5.3. *Flavorton (for copyright reasons) Matrix*

Future work will consider flavor as its own three dimensional matrix due to the immense controversy around whether boldness or cheesiness produces a more robust flavor. In our future work, we will explore empirical relations between the overall single number flavor profile and a three dimensional basis on spiciness, saltiness, and cheesiness. This conception would prevent the personal bias of taste testers, potentially grading high flavor due to only spice, only cheese, or only salt in absurd quantities. One could imagine the structure of potato chip flavors no longer being forced along a single axis, see Fig. 4, and instead represented by their constituent parts. This newly hypothesized, but not yet finalized flavor portfolio, has been described as the Flavorton Matrix, a new paradigm for descriptions of processed consumables.

6. CONCLUSION

In summary, we have explored various conceptions of how snacks can be categorized and described. We have determined that three keys characteristics dominate the overall sense of a snack: flavor, texture, and flatness. These are the key constituents of the Carbohydrate Matrix, a new window into the world of processed consumables. With this work, we have effectively ended the Snack Wars before they had a chance to begin, despite the insider pressures to promote features where a single product may dominate, while falling short in several key areas. They seminal work has shed new light into how we view processed snacks, and provides a gateway to several studies to improve the community perception and understanding of piquant consumable products. If corporations want their products evaluated onto the novel Carbohydrate Matrix, they are invited to send sample products to the authors for our consideration.

ACKNOWLEDGMENTS

Attention Deficit Hyperactivity Disorder, for without the first author's chronic daydreaming this matrix would have never been conceived. Former coworker and worksprint partner Tim Wright, for his agreement to philosophize snack food rather than do actual work. Reina and Roman for emotional support through several tummy aches. Sylvia's untreated sleep apnea resulting in many

midnight snack experiments. Hank the Rabbit, whose considerable mass provided an excellent under-the-desk foot warmer at all hours of the day and night. Donald Trump's fat stubby fingers.

Facilities: H-E-B, Posse East, vending machine in Physics, Math, and Astronomy building UT Austin.

Software: The entirety of all human written content ingested into artificially constructed neural network protocols synthesized to mimic human written language regarding processed food content.