Physical, Organoleptic, and Taxonomical Food Characteristic Analysis for Ontologies and Research

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As consumers, the first food characteristics that often come to mind arise as we make decisions about acquiring, preparing and eating food - for example the freshness of vegetables or meat, fruit ripeness, kinds of cuisine dish, availability of ingredients, and expense. Other factors such as preparation skill and time, and family or group scale consumption, and home storage capability, come into play. More broadly, as we try to engineer a more ecological, ethical and healthy food system, increasingly we need food choice metrics based on tracing food back to its time and place of origin, environmental context and method of production. We also want to track features arising from the interplay of social, geographic, and economic factors - labour conditions, food accessibility, nutrition to cost ratio - that arise within the distribution of food, and which ultimately affect both individual and population level health. A framework for organising food-related characteristics should be offered in one or more ontologies which can help harmonise the reference to food characteristics in both research and public health in a consistent and interoperable manner. Annotating datasets with a controlled, well-defined vocabulary of food characteristics, delivered in cooperatively functioning ontologies, should enable humans, and AI/machine learning tools, to overcome currently ambiguous roadblocks to data sharing.

We provide a brief explanation of how characteristics are generally handled by upper level ontologies such as the Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) (Masolo & Borgo, 2005), and the Basic Formal Ontology (BFO) (Arp et al., 2015), which OBO Foundry ontologies usually aspire compatibility with in conjunction with the

Relation Ontology (RO)(*Obo-Relations: RO Is an Ontology of Relations for Use with Biological Ontologies*, n.d.). We then offer a gap analysis of more immediate food characteristic vocabulary as found in various resources, versus what is being offered within the OBO Foundry family of life science ontologies (Jackson et al., 2021), which covers a number of domains relevant to food, such as food materials and products, additives, nutrients, allergens, diseases related to nutrient deficiencies and surpluses, and agricultural processes. We will detail helpful ontological distinctions in terms that identify classes of food material, their characteristics, and various processes that give rise to them. We don't attempt to cover the entire indirect landscape of food related characteristics here, but instead focus on inherent **physical and biological characteristics** of food materials themselves, then perceived **organoleptic characteristics**, and then **physiological characteristics** arising during and after food consumption which yield nutritional benefits and/or which may pose hazards.

Inherent physical characteristics include fundamental physical dimensions of material - weight, length (height / diameter / circumference), density, temperature, and reflected light frequency spectrum. There are often both subjective and objective ways of measuring these, for example, categorical terms such as hot, cold, frozen, blue, brown, or quantitatively using SI (International System of Units) units such as Celcius, centimetre, lux, and hertz. Compound physical dimensions such as viscosity, shear, and colour may involve a standardised intervention to measure (for example, a knife blade; a light source). Food chemical characteristics arise specifically in concentrations of nutrients, flavours, acids and bases, other functional food additives, and contaminants like toxins.

Focusing on organism characteristics, we examine plant and animal origins and growth: anatomy, taxonomy, varietals, and cultivars. Food related biological characteristics include age and ageing - the youth, maturity, reproductive rate and decay of organisms - and preservation terms which involve slowing down or halting ageing or perishability (Ferrucci et al., 2018). Many food materials and their derived products (like fat and oil) have pre and post harvest characteristics involving temperature and hydration (raw, dried, cold, warm) and characteristics arising from processes (frozen, thawed, cooked, roasted) which entail both a process history as well an amalgam of organoleptic characteristics - defined as those sensed up to the point of ingestion: smell, mouthfeel, taste, (aftertaste, umami, kokumi), and texture. Physiological characteristics follow as they are felt past the point of consumption, i.e. as digestion and nutrient assimilation occur; these can be divided into nutritive and non-nutritive characteristics described below. Hazardous food characteristics show up in various ways due to the physical, biological (pathogenic), chemical (including allergenic) hazard involved, and related ameliorative preservation and food safety preparation processes.

We touch on the ways in which food characteristic data can be represented and translated, and finish with a summary of areas where vocabulary needs to be developed and integrated with ontologies. We aim to show that a common language of food characteristics can satisfy different perspectives based on personal perception and cultural belief, biology, food science, and commercial law, among others, as long as the different senses of a term are itemised and reflected in a hierarchy of term labels and definitions.

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