Interfaces

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ABSTRACT

Whichever the origin from agro-ressources, their genetic diversity coupled with variability in agronomical practices and conditions leads to a more or less important heterogeneity of the raw materials that enter the processing chain. Efficiency and sustainability of processed foods depend in part on the process strategy to best valorize or at least deal with this heterogeneity. The interface between producer (agriculture) and processing (small or large scale) is thus a key point in the different sectors. It is also a point with major issues of quality, availability and price.

Further, the characteristics of agricultural products are expected to change because of new agricultural systems (less petrochemicals and fertilizers, development of organic production) and climate change. This will lead to different raw materials (new varieties with improved resistance to pests, adapted to new pedoclimatic conditions), to increased variability (more varieties, co existence of different agricultural systems), and increased heterogeneity (more abiotic and biotic stresses…). New agricultural systems may also introduce new risks in the food chains (presence of mycotoxins, of thermophilic bacteria in compost), which may modify the processing conditions needed to produce safe foods. This is a challenge to the food industry as the consumers expect a constant quality.

Until now, food industry has reacted to variability and heterogeneity of raw materials by increased standardization. A common strategy is to fractionate the raw materials and then recompose the food, using eventually additional ingredients. This energy, matter and water-intensive strategymay further generate pollution streams, and thus negatively impacts sustainability. Furthermore, it does not use the functionalitiespresent in the raw material and ignores foods that may be appreciated by consumers. Another approach consists in establishing contractual relations with the producers, with mutual obligations in terms of volume, quality and price. However this is not universal, as some sectors rely on a worldwide market (e.g. cereals) or others, notably for fruit and vegetables, depend on the surplus from fresh markets (apple, mango, apricot…) , with major issues in availability, both for quality and quantity. This is why this project will focus on fruits as a particularly good example of large variability and heterogeneity, with variety and pedoclimatic conditions being major factors on a large scale, with more or less rapid evolution during maturation and storage on a temporal scale, and with heterogeneity between individual fruit pieces linked for position on the tree for example, which are more difficult to average than for less discrete food raw materials (milk, cereals…).

Market organization is another way to deal with raw material heterogeneity, through private standards or contractual agreements. Private actors of the market, at the demand side, may have a determinant effect on the farmers’ adoption of practices increasing raw material safety (Codron et al, 2014). Producers’organizations, at the interface between producers and food processors, play a major role in the management of raw materials heterogeneity. However they may contribute to a decrease of the diversity of agricultural practices and consequently raw products quality through technical advices (Naziri et al, 2014). One critical point is also the organization of practices’ audit within producers’ organizations.

Fruit composition affects the characteristics of the processed fruit and vegetables; this is almost quantitative for macrocomponents such as sugars or acids, where the fruit type and variety give a signature composition that is recognized in the sugar/acid ratio of the finished product. This is also true but already more complex for micronutrients: for example, polyphenols’extraction to juice depend on the polyphenol composition but also the fruit acidity, cell walls and maturity, and external factors such as pressing temperature (Renard et al., 2011). The more complex properties are the ones that are the least understood: in terms of texture for example the raw fruit texture is not a good predictor of the texture of the processed products such as mumps, slices, purees (Bourles et al., 2009; Missang et al. 2011, 2012); however this has been little investigated so far and there is a major lack of knowledge as to the

mechanisms.

This differential response to processing should be taken into account at two levels: to orient fruits towards a precise processing stream, and to better optimize process operations. To orient fruit streams it would be necessary to identify indicators of structure, composition or evolution; much research has been carried out on determination of fruit composition with simple, non-destructive methods, and infra-red spectroscopy has proven to be efficient for determination of total soluble solids, sugars or acids (Bureau et al., 2009, 2012, Scibisz et al., 2011), above other simple methods and even NMR metabolomics (Bureau et al., 2013). However it stays poor at texture prediction. This is why it will be prioritized, together with more physical characteristics such as density.

For modeling we actually have on one hand, agro-ecophysiological models of development of fruit during their growth on the plant as modulated by climatic factors and cultural practices. These models simulate the accumulation of carbon or water and dry matter, and in a few instances of some constituents (sugars, acids, ...). The effect of pre-harvest factors on fruit quality has been poorly studied. Ecophysiological models have focused on modeling organ growth in dry weight using so-called "photosynthesis driven models" (Gary et al., 1998; Marcelis et al., 1998), which consider the plant as made of few big compartments (leaf, wood, fruit) in which carbon is accumulated. Modeling fruit growth has been improved by considering meristematic and non-meristematic tissues as in apple fruit (Austin et al., 1999) and tomato (Fanwoua et al., 2013). But fruit and grains cannot be restricted to their carbon content or dry weight simply because water is their main component. A model of fruit growth integrating dry matter and water accumulation within the fruit has been developed (Fishman and Génard, 1998) and opened the way to consider quality. Fruit compositions are still absent from most models, though Génard and Souty (1996) designed a model to predict the sweetness of fruit based on carbon partitioning into various sugars. Lobit et al. (2003) and Etienne et al. (2014) have designed models predicting fruit acidity.

On the other hand, the products processing models describe the phenomena of mass and heat transfer, deformation and chemical reactions taking place within the food. The extent of these phenomena depends on the operating variables of the process. These predicted phenomena have a major impact on the organoleptic or nutritional characteristics of the product

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