Coffee is a complex and “volatile” food whose sensory quality is affected by endogenous chemical reactions involving the formation of aromatic compounds most influenced by pH, water activity and the external effects of temperature, storage and packaging. Packaging has an important influence in coffee processing, storage and marketing. Changes in coffee sensory attributes of specific packaging systems and their environmental sustainability have nowadays become almost compulsory. Controls of possible interactions between coffee processing and packaging are therefore necessary because of its possible influence on the sensory quality of the final product over time (1-2).

The shelf-life is defined in food science as a period of time over which the quality of the product decreases by a specified amount. A simplified definition of sensory quality is given by the shelf-life, which is often used to describe the desirable sensory characteristics of the product over the whole period of time over which it is consumed.

This methodology must be based on the direct measure of product shelf-life under the conventional conditions of storage of the product(s) and can easily be developed for perishable foods in which the decay occurs quickly, but it is more complex for a stable food such as roasted coffee powder that has longer shelf-life. In this case, the shelf life is indirectly assessed by acting on factors that may influence the quality depletion pattern.

This study aims to define the evolution of coffee aroma stored under different conditions (stressed and conventional) as a function of time by packaging through an untargeted aroma-fingerprinting and profiling approach by means of SPME-GC-MS method. In particular, the project aims 1) to propose a model of the kinetic evolution of aroma active compounds and 2) to look at the chemical markers of coffee degradation that could be used in combination with sensory data to define the shelf-life of coffee.

Preliminary analytical results show that the untargeted fingerprinting approach fails in the definition of a kinetic model that correctly describes the decay of the coffee powder over time due to the complexity of the coffee aroma and that a detailed study dealing with the changing of the aroma profile must be done.

Aroma fingerprinting exploration of the different packaging and storage conditions over time by PCA elaboration shows a clear relationship between storage conditions and the same data set but not the same data set but with a different modification in the variable factor composition. In particular, under the conventional condition, the time over the 180 days is evident and linear regardless of the type of packaging (Fig. 2a). On the other hand, under stressed conditions, samples are unevenly scattered on the plot highlighting a packaging-related aging that affect the aroma quality of the coffee (Fig. 2b).

The relationships between the variation of the aroma fingerprinting over time have to be mentioned in order to define a kinetic model. This evaluation has been done through a PLS algorithm following the scheme 1.

A kinetic modeling has first been carried out on a training set of samples and its ability to predict correctly the aging of the samples has been checked through a test set of samples within each packaging. PLS results show a good fitting between aroma storage and time with standard packaging A even with conventional or stressed storage conditions (Fig. 4a), although the kinetic model fails with the prediction of coffee aging in particular when paired with packaging B (Fig. 4b). Different responses in C and D under stressed conditions (Fig. 4c). Under these conditions, a predicted time of at least equal to the real one (180 days) was expected because of the predicted kinetic model. The model is fitted to the data and it is related to specific quality markers that are able to correctly describe the sensory decay over time.

Table 1 shows the variables better correlated to time under stressed storage conditions with the different packaging. The variables which exhibit a kinetic trend as a function of time are in red, and in green those that decrease. As can be noted, compounds such as 2- butanone, hexanal, undecanal are always positively correlated to time, albeit to a different extent depending on packaging, the same is true for anisoleurene or 2,3- tetrahydrofuran. These results highlight different behaviors of some compounds depending on packaging, e.g. acetic acid and 4-acetamido-3-furoic acid which have a reverse trend with packaging C, when compared to the others (Fig. 5).

The aroma profiling approach allows us to follow the kinetics of volatile markers over time. The different permeability of packaging influences the composition of coffee aroma over time and, as a consequence, it’s aging. Partial Least Squares-Discriminant Analysis (PLS-DA) has been employed to create a classification model in terms of a defined category (packaging) on the basis of the aroma compounds. This model has made possible to assess whether the samples were classified in function of aging within each package and to determine which compounds better characterized the packaging in terms of aroma.

Table 2 presents the results of the kinetic modeling approach of coffee aging. The coefficients of determination are different for each bagging system and conventional and stressed conditions. A.F.S. - packaging C, Conventional, S-stress.

Although other authors have already worked on aging markers of coffee, their studies have mostly defined markers of four main aging phases and determinants for a product with such a long shelf-life (3-4). Moreover, it has to be noted that the already reported results do not involve shelf-life data but an in-depth investigation of food kinetics studies is still needed. Our study sheds light on the definition of a criterion for the end of a product life that involves not only the product but also its packaging. These preliminary results show that the evolution of the aroma compounds during the storage on the different coffee packaging is very different and mostly related to the packaging condition. These complex phenomena are difficult to be correctly described through a fingerprinting approach but require in depth specific market studies in order to define a kinetic model suitable to describe the aging of coffee under conventional storage conditions. In particular, coffee packaging is considered. In order to obtain the shelf-life of the roasted coffee powder, these results must then be correlated to the sensory evaluation data whose define the product acceptability limit.