New Aspects of Coffee Processing: The Relation Between Seed Germination and Coffee Quality

D. SELMAR, G. BYTOF, S.-E. KNOPP

Botanical Institute, Technical University, Mendelssohnstr. 4, 38106 Braunschweig, Germany

SUMMARY

Quality of green coffee depends on the processing method. Up to now, these differences were attributed exclusively to differences in the original material used for processing. This explanation neglects the occurrence of metabolic reactions that run in the living coffee seeds and strongly depend on the physiological status of the beans. Coffee seeds are recalcitrant. This means that seed germination is already induced while they still are within the fruit. However, further development is suppressed, either by the osmotic potential of the fruit flesh or by germination inhibitors. Consequently, rather than dormant seeds, coffee beans represent germinating seeds which are blocked in their further development.

In contrast to wet processed green coffee beans, where the fruit flesh is removed directly after harvesting and thus the inhibition of further development is neutralised immediately, in dry processed coffees, the inhibition should be maintained throughout processing. Accordingly, the germination status, and thus the mobilisation of reserves influencing the composition of aroma precursors, should be quite different in wet and dry processed coffee seeds.

The processing of identical original material by both methods in parallel leads to significant differences in the cup quality of the corresponding roast coffees. These differences are based on metabolic reactions within the coffee seeds that differ markedly depending on the mode of post-harvest treatment. These reactions mainly comprise the mobilisation of reserves, liberating low-molecular substances. These, like free amino acids, are potential aroma precursors and thus influence the coffee quality. In this context the quantity and quality of free amino acids of wet and dry processed coffees was analysed. In all cases the total content of amino acids was higher in washed green coffee beans than in the corresponding dry processed ones, verifying cogently the hypothesis mentioned.

INTRODUCTION

In general, coffee processing is performed either in the dry or in the wet way. In the course of wet processing, first fully ripe coffee cherries are mechanically pulped. The resulting parchment beans are still covered by mucilaginous residues of the pulp, which are degraded during a one or two day tank fermentation. Thereby the pectins are hydrolysed and the remaining mucilage is washed off. After drying, the resulting parchment coffee is hulled, and the green coffee beans can be stored and shipped. In contrast, in the course of dry processing, the entire coffee cherries are dried directly. After husking, the green coffee beans are also ready for shipping.

It is well accepted that there are significant quality differences between the differentially processed coffees. In general, dry-processed coffees are characterised by more body, whereas wet-processed ones reveal a better aroma resulting in a higher acceptance. These undeniable

differences are widely attributed to the fact that wet processing requires a proper sorting of the fruits, because only fully ripe coffee cherries can be pulped correctly by the mechanical pulpers. Moreover, the entire wet processing requires a more thorough proceeding than the dry one. However, there are some hints in the literature, that also wet and dry processing of coffee cherries of the same quality resulted in different flavours (Chassevent et al., 1970). Thus, the question arises, if – apart from the differences of the original material used for processing – also the metabolic reactions running in the coffee beans during processing contribute to cup quality, depending on the type of the processing method used.

This work is aimed to analyse if the observed quality differences in differently processed coffees are exclusively due to differences of the original material or if they also are caused by metabolic processes occurring in the seeds during processing.

Plant physiological background

To understand the processes occurring in coffee seeds during processing, one must realise that processed green coffee represents living organisms, featuring various metabolic activities. The nature and extent of these reactions depend on the physiological status of the seeds, which among others is influenced by the water activity of the seeds. In moist seeds, i.e. during early stages of processing, the metabolic activity should be considerably high, whereas in dried ones (in the final stages of wet or dry processing) these reactions are strongly reduced due to the low water content.

Like many other tropical seeds, coffee seeds are characterised as "recalcitrant" (Roberts 1973; Ellis et al., 1990). Unlike “orthodox” seeds (e.g. wheat or peas) they do not undergo a dormancy period initiated by maturation drying. Instead, ripe coffee seeds have a water content as high as 45% (wet basis). This means that in principle they are able to germinate within the fruit (Ellis et al., 19991). However, the endogenously induced germination is obviously suppressed, either by the high osmotic potential of the fruit flesh as in the case of cocoa (Rühl et al, 1988), or by germination inhibitors like in tomato seeds (Bewley and Black, 1995), or by phytohormones like in avocados, where the germination is inhibited by absisic acid (Sembdner et al., 1988). Consequently, rather than dormant seeds, coffee beans represent germinating seeds which are blocked in their further development. Indeed, up to now it is not known, which active inhibiting principle is realised in the coffee fruits, but it is very likely that it is located - like in the other fruits - within the pulp. Thus, as soon as the seeds are taken out of the coffee cherries, i.e. when the fruits are pulped, the formerly blocked germination processes are un-locked and a typical germination metabolism can be initiated. This also applies for beans germinating out of fruits that had been shed onto the soil. Only after extensive decomposition of the pericarp – a process that can take several weeks – the germination in the coffee beans proceeds, resulting in radicule protrusion and seedling growth.

Coffee quality and seed germination

One of the characteristic features of germination metabolism is the mobilisation of reserves, i.e. fats, proteins and polymeric carbohydrates. By this, free amino acids and soluble carbohydrates should be released, which – with regard to coffee quality – represent important aroma precursors that give rise to the characteristic coffee aroma compounds during roasting. Summarising the facts so far mentioned, it can be concluded that the quality differences of technologically differently processed coffees must be influenced significantly by the metabolic processes running to different extents in the green coffees treated in the respective two ways. In the course of dry processing, the pulp (and thereby the inhibiting agent) remains

around the seed for the entire period. This means, the inhibition of further germination persists and thus the metabolic processes running in the beans should not change drastically.

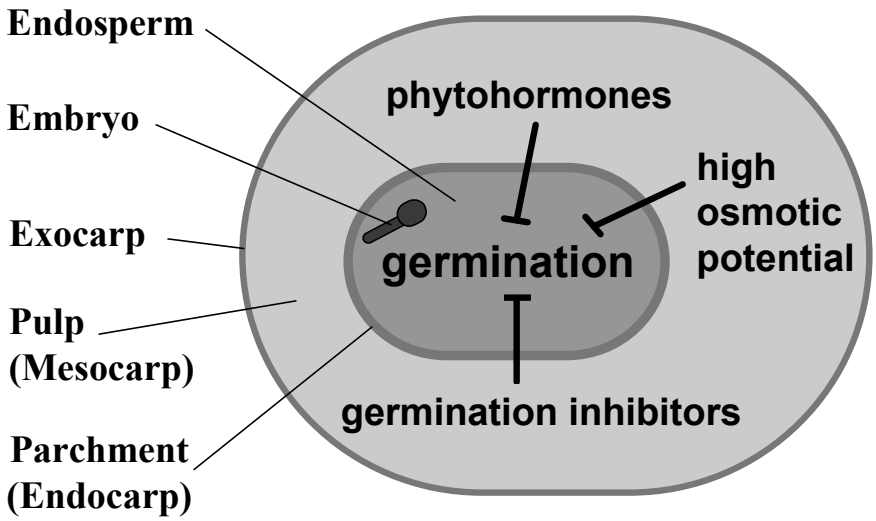

Figure 1. Inhibition of germination by active principales located in fruit flesh (pulp) of coffee seeds

Wet processing commences with the removal of the pulp, relieving the seeds from the germination inhibiting effect. The presence of sufficient water in the fermentation tanks guarantees further imbibition of the seeds. As a consequence, the germination metabolism is unlocked, leading to the mobilisation of reserves and thus to the liberation of potential aroma precursors. Hence, the question arises if the period during the wet processing, in which this metabolism takes place, is long enough to produce significant amounts of aroma precursors and to increase aroma quality. In this context we have to consider that active metabolism persists not only during the actual fermentation phase, but also in the initial period of the subsequent drying. Altogether there is a time window of 3-6 days until the water content of the seeds decreases to a point where the metabolic processes are slowed down to very low rates.

Within the next chapters we present evidence that the quality differences of washed coffees compared to dry processed ones indeed partially derive from the physiological activities within the seeds during this space of time.

MATERIALS AND METHODS

Processing

For both experimental lines – original processing and model processing in Braunschweig – exclusively ripe fruits of *Coffea arabica* L. were used. Fruits of the variety *Acaiá* were kindly provided by Ipanema Agricola Ltda., Alfenas, Minas Gerais, Brazil. Fruits of the variety *Caturra* were kindly provided by Cenicafé, Chinchiná, Colombia.

Processing in Brazil and Colombia

Wet processing

Freshly harvested fruits were mechanically pulped and submitted to tank fermentation for 22 h and 16 h (*Caturra*), respectively. Subsequently the washed parchment coffee beans were

dried on a separate plot of the plantation's sun terrace (*Acaiá*), and in mechanical dryers (*Caturra*), respectively. After 6 d (*Acaiá*) and 2 d (*Caturra*), respectively, the desired water content of 12% (wet basis) was achieved. Within 4 weeks the dry parchment coffees were sent to our lab in Braunschweig, where they were manually hulled and used for roasting. Aliquots were stored in a freezer (–70°C).

Dry processing

Mature coffee cherries from the same batches used for the wet processing were manually selected and dried as whole fruits on the sun terrace for 12 d (*Acaiá*) or 14 d (*Caturra*), respectively, until the desired water content of 12% was achieved. Within 4 weeks the dried cherries were sent to Braunschweig, where they were manually husked and used for roasting. Aliquots were stored in a freezer (–70°C).

Model processing in the laboratory

Fully ripe fruits were harvested on the coffee plantation in Brazil, subsequently transferred into "styrofoam" boxes, and sent to Germany by cargo express flight. To prevent the fruits from decomposition during the transport, some plastic bags containing ordinary ice cubes were added. Three days after harvest, the fruits arrived in Braunschweig and were subsequently submitted to model processing. During the laboratory processing periodically samples were taken and stored at -70°C for later preparation and analysis.

Wet model processing

The fruits were manually pulped and the mucilaginous parchment beans were transferred to 5 L-Erlenmeyer-flasks adding an excess of fresh water. The coffee was model-fermented under the ambient conditions of the laboratory for 36 h. During the procedure, the water was exchanged three times. The resulting parchment coffee was dried in an standard laboratory drying oven at temperatures of 35-40°C. The desired water content of 12% (wet basis) was achieved after 5 d. The beans were manually hulled. Whereas the main part was roasted, small amounts were stored at –70°C for further analysis.

Dry model processing

The mature coffee cherries were dried in a common laboratory drying oven at temperatures of 35-40°C. After 12 d drying was accomplished. The beans were manually husked and either used for roasting, or stored at –70°C for further analysis.

Extraction of free amino acids

The stored coffee seeds were transferred into liquid nitrogen and – after adding norvalin as internal standard – crushed to a fine powder. The coffee seed powder was repeatedly extracted with sulphosalicylic acid (4%).

Derivatisation and determination

The OPA-derivatisation procedure was accomplished according to Kirchhoff et al. 1989, however a Spark Holland Midas Autosampler was used for derivatisation and sample injection. The derivatives were separated on a C18 column (Nucleosil 100 5µm Macherey and Nagel 250 x 4,0 mm) using a binary gradient (MeOH, ACN, H_2O) with a flow rate of 1,3 mL/min. The derivatives were detected using a RF-551 Shimadzu fluorescence detector (334

nm ex; 425 nm em) and quantified using an external standard of a mixture of amino acids.

Roasting and sensory assessment

The roasting of the different green coffee samples was carried out by the DFA (Munich-Garching) using a Probat BRZ4 sample roaster. The sensorial assessment was accomplished by a sensory panel (11 members) of the DFA. The aroma was evaluated in triangle tests.

RESULTS AND DISCUSSION

In the experiments, identical material was used for both coffee processing methods in parallel and subsequently used for analysis. For the first time, not only green and roasted coffee beans, but also the respective "progenitors", i.e. the fresh coffee seeds and the intermediate products of green coffee preparation, have been analysed. Extensive sample preparation experiments which included original post harvest processing in the producing countries (Brazil and Colombia) and laboratory model fermentations, yielded substantial material for coffee analysis.

The sensory evaluation of the roast coffees revealed that the dry and washed coffees could be distinguished with high significance (11 of 11 panel members). In the hedonic evaluation of the overall aroma impression 9 of 11 panel members classified the "dry" roast coffee as less acceptable. These results represent an unequivocal proof that the reasons for the quality differences of technologically differently processed coffees are not exclusively due to the differences of the original material but must also be caused by the processes taking place in the beans during processing. These data confirm results from experiments of Chassevent et al. (1970) who also analysed green coffees which were obtained by applying the different processing methods on similar original material.

It is scheduled to supplement our sensory analysis by detailed analysis of the aroma impact compounds by GLC using aroma extract dilution analysis (AEDA, Grosch, 1996; Grosch et al., 1996). These studies have been initiated recently in the laboratory of Prof. Schieberle (DFA Munich).

In order to register the differences in the metabolic processes running in the differentially processed coffee beans the content of free amino acids in the raw coffee beans was analysed. Free amino acids represent typical products of reserve mobilisation, which also reveal a high significance as potential aroma precursors. Quality and quantity of free amino acids of those green coffees, which were obtained respectively from the authentic, and from the model processings, were determined. In each case the total content of amino acids was higher in washed green coffee beans than in the corresponding dry-processed coffees (Table 1).

These results were also confirmed by Casal et al. (2001) and also could be calculated from former data of Arnold and Ludwig (1996). These findings clearly demonstrate that during processing, the concentrations of potential aroma precursors change to different extents depending on the mode of processing, supporting the hypothesis mentioned above.

The time course of the liberation of amino acids points out that the content of free amino acids is determined by complex processes. Obviously, the release of amino acids – as a result of the hydrolysis of storage proteins – is overlayed by the consumption of amino acids in the course of various metabolic processes, e.g. protein biosynthesis. Whether the marked decrease of free amino acids in the first phase of wet processing is due to wash-outs in the course of fermentation, or if it reflects a general anabolic metabolism of germinating seeds remains to

be elucidated. Corresponding analysis using authentical material from original processings in Brazil and Colombia is in progress.

Table 1. Total content of free amino acids in wet and dry processed green coffees

	free amino acids [mg / kg f.w.]	
	dry processing	wet processing
plantation (Columbia)	2,760	3,070
plantation (Brazil, A)	3,570	4,310
plantation (Brazil, B)	4,030	4,360
laboratory (Germany)	5,050	5,400

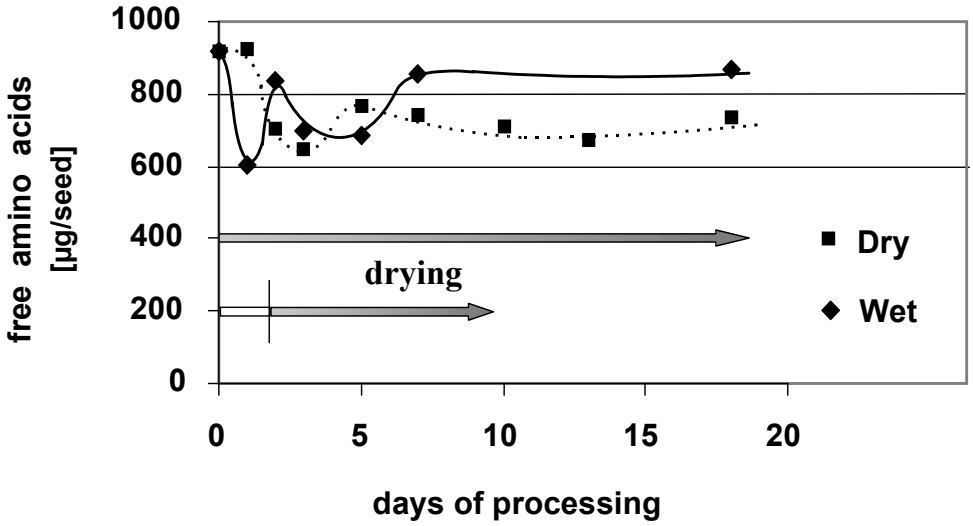

Figure 2. Changes in the content of free amino acids during model processing

Therefore, it is essential to use an additional marker for the registration of the differences in the germination status of the differentially processed coffees. One of the first metabolic reactions in germinating seeds in general is the onset of the glyoxylate cycle. It is planned to use the gene expression of the key enzyme for this metabolic pathway – that of the isocitrate lyase – as corresponding germination marker. A homologous probe of this enzyme is already synthesised and will be used for the forthcoming quantifications.

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