A Critical Appraisal of Coffee Drying in Kenya

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SUMMARY

Coffee drying is the most critical phase of the coffee processing chain in. Normally, it also imposes serious challenges to the processors for being highly dependent on the solar energy, an input whose reliability can be impaired sometimes by prevalence of overcast, cloudy and rainy periods. This can cause prolonged drying even at critical stages of high moisture content, which is detrimental to the production of high quality coffee. Generally, the drying tables require vast areas out of the limited available land besides being labour intensive. These tables need regular repair and maintenance as well leading to frequent additional costs. Some other adverse aspects inherent to the drying process can however be checked by controlling the drying rate or exposing coffee to the sun at a certain phase of drying. These limitations among others have been stimulating the need for alternative coffee drying technologies. However, there has been very limited adoption of new innovations to at least supplement the drying tables particularly in the cooperative sector. As such, there is still need for further search for appropriate dryers. In view of this, the important outputs towards overcoming the critical constraints, which have been encountered with are discussed. Recommendations are also made on the way forward for the sake of sustaining the high quality of Kenya coffee particularly with respect to safety and health requirements.

INTRODUCTION

In Kenya, arabica coffee is mainly processed by the wet method with only very small unsuitable amounts, being committed to dry processing. The resultant parchment coffee is mainly sun dried because the final quality of such coffee is also highly appreciated despite its demand for labour and capital in substantial proportions (Wootton et al., 1968). However, this process also requires labour, capital and land in substantial proportions (Whitaker et al., 1984). Since it can also take up to 14 days on average to dry the coffee, the capacity of the drying tables must accommodate coffee harvested within 2 weeks. The drying process takes place in distinct stages identified by percent moisture content (MC%, wb) to including: Skin drying (55-45 %), White (45-33%), Soft black (32-22%), Medium black (21-16%), Hard black (15-12%) and, fully dry (10.5-11%) for parchment. The coffee cherry which is intended for dry process is simply dried from 65% to 12% MC (Kamau, 1980).

Initially, coffee drying must be rapid, and involves vigorous stirring and if necessary using heated air to remove the surface water and that between the parchment hull and the bean the shortest time possible within a day. The following white phase has to be slow and cool to avoid parchment cracking. Otherwise, subjecting wet and dry parchment to 38 $^{\circ}$C and 57 $^{\circ}$C can cause sourness in the liquor besides promoting uneven drying. During the soft black phase, exposure to the sun for an accumulated 50 sunshine hours induces some very attractive quality attributes to the coffee via ultra violet rays of the sun radiation. However, in a hot, dry weather, the rate of drying under fully exposed conditions can lead to a total drying period so short that the photosensitive reactions which appear to play a part in the development of quality do not have time to reach completion. Such coffee tends to be yellowish or brownish as well (Wootton et al., 1968). Mechanical drying is discouraged within this phase (Kamau,

1980). At 12% MC, the coffee can remain on the tables for long, if adverse weather prevails, supporting the practice of transferring such coffee from the tables to ventilated storage to pave way for relatively wetter coffee (Wootton, 1968).

Once coffee has been committed to the drying process, it must be ensured that it dries steadily as the drying status may require and devoid of reversing due to re-wetting. Hindered drying conditions should be overcome by provision of any suitable technology. Coffee should not be allowed to over-dry since valuable weight will needlessly be lost and coffee becomes pale yellow an attribute that is related to poor quality. Besides, over-dry coffee reabsorbs moisture thereby getting rewetted with a loss in quality. However, it is better to over dry slightly instead of under drying since a little moisture re-absorption has insignificant undesirable impact on coffee quality while under drying creates conditions conducive to mould growth. It is important therefore, that all the critical points during the drying process are controlled. How this has been done and the way forward in this regard is subject of this paper.

THE CRITICAL CONSTRAINTS AND THE CORRESPONDING REMEDIAL MEASURES

Microbial activities during Skin drying

It is evident that the fully wet state of freshly washed parchment provides conditions suitable for the development of microbial activity leading to onion flavour and other taints (Wotton et al., 1968). In order to avoid this hazard, it is essential to get wet coffee through the skin-dry stage within the shortest time possible in a day. This means a rapid rate of drying, maximum exposure to the sun and continuous stirring of the beans spread in a thin layer on the skin-drying tables until the surface water and that between the bean and the hull is removed. Coffee can be skin dried with warm air without heating beyond 35 °C. After skin drying, the parchment should be transferred to final drying table on the same day to prevent rewetting through dew formation on metal tray wire, which can occur reverse the gains made during the day.

Parchment cracking in the white stage

As soon as the coffee is skin-dry, the parchment begins to crack unless it is immediately shaded. This occurs if rapid and hot drying was adopted in this phase since the parchment hull would dry faster than the bean and raptures in an attempt to shrink over an otherwise swollen bean (Mburu, 1999; Wootton et al., 1968). Cracking can expose the bean to microbial attack, induce contamination from the ambient environment besides ageing and hence loss of coffee quality. The parchment should also be shaded from the intense sun between 10.30 am and 2.30 pm to ensure that it remains cool, but continuously ventilated via regular stirring. The minimum residence time in this phase is signified by change of colour from white to black accompanied by minimum parchment splitting. Intact parchment will not crack afterwards.

Sunlight requirement at the soft black stage

The beans at the soft black stage are elastic, translucent and allow the formation of the final colour of the bean. Sunlight (UV solar radiation) is therefore very essential because formation of the raw bean colours as well as the improvement of the chemical quality is photosensitive at this moisture level. Since drying is not very critical in this phase, an increased layer depth and stirring vigorously can be practiced if it gets too hot. However, for the remaining days to fully dry, coffee should be spread to a depth of 2.5 cm, more thinly in poor weather and

stirred frequently. It should also be kept under ventilated shade cover from 10.30am to 2.30 pm in hot weather (Mburu, 1999; Wootton et al., 1968).

Mixed drying

Mixed drying of coffee can contribute to uneven roast and light acidity in the coffee. Therefore, the relevant measures must be in place to check such an undesirable aspect. The design of the current coffee drying table for instance is meant to ensure that it remains absolutely flat, which is essential for thorough stirring and thus even drying of the coffee (Sonke, 1968). Other important features include a suitable width to ensure that one can stir the coffee to the middle from either side for even drying. These tables have a wooden framework on top of which are chicken and tension wires with adjustable J-bolts to keep them flat all the time. Scheduled repair and maintenance of these tables is therefore very crucial to prevent them from sagging and hence inducing mixed drying. Mixed drying is also avoided by drying coffee lots harvested at different times separately on the drying tables until they are fully dry. This applies also to dry processed cherry instead of allowing them to accumulate in heaps located sometimes in dump places pending attention at the end of the processing season.

Protection from adverse weather

Sun drying of coffee on the conventional tables can expose the coffee to extreme weather conditions. However, recommended suitable protection of the coffee from adverse weather is available. Covering materials like a “Nylex” P.V.C. or polythene films 1 m wide are for instance safely used for covering coffee at night and in dull/rainy weather during the day as alternatives to “sisal-craft” paper provided the coffee is wrapped in Hessian or sisal cloth to unsure that it is not in contact with the covering material; and the covering material is not passed underneath the coffee, which must be ventilated from below. An evepy reinforced P.V.C. covering can also be safely used over coffee drying tables provided the coffee is wrapped in hessian or sisal cloth. It is however, worth observing that covering coffee in the middle of the day from 10.30 am to 2.30 pm, every day even though the weather may be dull and cool merely serves to lengthen drying times and so increase pressure upon drying space with no compensating advantage.

In a hot and dry day, coffee should ideally be stored under a roof some distance above it, which can be very much cooler than its exposed counterparts. However, in practice, heaping the coffee longitudinally on the table coupled with vigorous stirring instead of covering is recommended to protect the coffee from intense heat from the sun (Wootton et al., 1968). A double-layer of hessian over a shallow layer of parchment coffee does not prevent the coffee attaining about the same temperature as fully exposed parchment.

Drying space limitations

The lack of adequate space for sun drying coffee can cause congestion in a primary coffee-processing factory thereby impairing the capacity of the factory to receive coffee in a timely manner as it ripens in the farms. The resulting delays in harvesting can have adverse effects in the processed coffee. Sun drying space has become increasingly limiting due technological advance in farming, hindered attributed to unreliable climate; prolonged skin drying periods during long rain spells or when the weather is very dull and cold; lack of enough well maintained drying tables, labour availability and management, some social implications and the absence of suitable equipment to supplement the drying tables. Shortage of tables can arise from limited factory land and deterioration of the drying tables caused by failure to maintain and repair them as required. Congestion can also occur where the cherry delivery to

a factory exceeds its design cherry intake capacity. Such adverse conditions can compromise the coffee quality perhaps by inducing mould formation. Since the main constraint arises from adverse weather, coffee drying trials were conducted within the global coffee project (Mburu, 2005). The results showed that the low frequency of initial OTA producers did not develop into significant OTA outcomes that could be ascribed to the treatments. These experiments also proved to regularly contain OTA-producing fungi. However, individual replicates were occasionally far removed from others. The quality of the coffee from all the treatments was poor (Class 5-8) possibly due to the prolonged drying (12-20 days), thick coffee layers (4-8 cm) among other factors.

Since fully dry parchment is normally at equilibrium with a relative humidity of 60% at 20 °C, coffee can dry to about 12% beyond which it can take as many as 8 days (Wooton et al., 1968) without attaining the fully dry status as long as the wrong RH% prevails. However, a suitable 9th day can see the coffee through to full dry within 2 hours only. At the same time, the drying rate might be too slow from the soft black stage during overcast condition due clouds. For these and other reasons, the very wet coffee can miss drying space on the tables because of congestion. These findings paved way for studies to consider the following options for sustaining an adequate capacity at the drying stage through scheduled repair, maintenance and expansion of drying tables, more adoption of coffee driers and ventilated conditioning/temporary storage bins as well as improving the operational and labour management.

Coffee drying tables

In Kenya, sun drying of coffee has been most preferred in comparison to mechanical drying and this has produced the best quality coffee. However, though congestion due to shortage of drying tables sometimes causes a reduction in the quality of the dried coffee, the remedy is not the building of more tables since many factories do not have or are unable to purchase the necessary land and/or do not have sufficient labour to operate extra tables. As such, this can become critical as plantings in the smallholder sector begin to expand the overall yields. The status of the existing tables must however, be confirmed to be in good order first and the necessary repairs if any done before considering expanding the drying space. Otherwise, doubling the coffee depth on the tables from the soft black to fully dry phase can also serve to over come congestion. The available factory land for the drying might also be the limiting factor for expansion. In such a case, it would be prudent to consider the services of a coffee dryer.

Conditioning bins

If the coffee is on the table for so many days without attaining fully dry status during adverse weather conditions, the factory would be experiencing serious congestion. This is just an example of the sort of frustrating circumstances, which justify the construction of ventilated conditioning bins to which it is advisable, therefore, to transfer nearly dry coffee for temporary storage in poor weather and so free drying tables for wet coffee. Such coffee must however, be returned to finish off at the tables when warm and dry conditions return or at the end of the harvesting season. In this regard, ventilated and manually stirred conditioning bins have been playing an important role in the estate and cooperative coffee sectors respectively. Further to that, ventilated bins not only eliminate heating, but also actual cooling is achieved. Finally, the total capacity of the bins should be sufficient for at least one week's production, or about twice as much as can be held on tables.

Soaking

Soaking of parchment after final grading can enhance the factory capacity by allowing further cherry intake even when congestion is prevailing. Since parchment can be soaked for a maximum of 7 days without deterioration in quality (Mburu, 1997), implementing such a practice would enhance the capacity of a factory to process more coffee particularly when drying is seriously affected by adverse weather. Soaking can actually play a pivotal role at the peak season within which 20% of the seasons harvest is expected within 2 weeks. The soaked coffee would then be dried when congestion eases.

Coffee driers

In view of the need to provide solutions to the constraints causing congestion in a coffee factory, the technical performance of alternative driers like ***PVC Tents*** or simple ***Plastic cover*** projected over the coffee (Kamau, 1982) for skin drying even when there is bad weather/rain and during the night; ***Drying trays*** (Anon., 1990) for wet parchment and which can be stacked on racks under a corrugated iron shed; ***Rotary drum*** and ***Batch*** driers (McCloy, 1960; Mburu and Mason, 1993); ***Sack driers*** (McCloy, 1959); ***Silo*** drying unit (Kamau, 1980); ***Low Continuous Column*** drier (Type BSR 133) (Kamau, 1980); ***Ventilated conditioning bins*** (McCloy, 1960); A ***new parchment Solar*** drying system (Trim et al., 1984) and Parabolico driers (Global Coffee Project, 2004) were evaluated. Other preliminary studies focused on driers for the small holder sector like the ***ITIPAT*** drier from Cote de Ivoire; ***cabinet solar*** drier from UCDA, Uganda); as well as ***concrete barbeques***. Although, some driers were capable of relieving tables when the weather could not permit parchment drying to fully dry or when the cherry intake was beyond the table capacity, loading in some of them was very laborious. These perhaps are some of the reasons why adoption of these driers has been very limited particularly in the cooperative sector despite accrued savings in labour (normally used in opening, covering tables and moving coffee) and the accelerated drying period by 7-11 days (Kamau, 1982) because of the ability of some of them to dry wet parchment even during the rain. All the same, mechanical drying has also been observed to reduce the drying period quite considerably and in some cases the ratio was 1:8. In general, therefore, few if any mechanical dryers have been installed in cooperative factories principally due to their high cost and technical sophistication but they have been employed in the estate sector for many years. However, the search for, new parchment drying systems for cooperative and smallholder factories is still in progress to supplement the sun drying of coffee in order to salvage coffee which could otherwise be ruined by lack of drying facilities during the peak period when weather is also not ideal for drying.

Specifications for coffee driers are as follows: The dyer must be indirectly fired and the fuel used specified. It should dry coffee from 55% (wb) to 33% (wb), and 23% to 10.5%); If not 55% (wb), then the highest moisture that it can safely handle should be indicated; The temperature of coffee beans should not exceed 35 °C at any time during the drying cycle. The total power requirement of the installation should be indicated in Kw; The average fuel consumption of the heat source per unit tone of coffee dried should be given for both moisture content ranges; The capacity of the dryer or batch capacity range should be indicated; The approximate drying time to dry from 55% to 33% and 23% to 10.5% should be indicated for the average ambient conditions of 25 °C dry-bulb temperature and 60% relative humidity; Installation requirements of the drier should be stated and drawings provided for this purpose; The minimum requirements of equipment necessary for loading and unloading the drier should be included in the supply; Possibility to offer an automatic moisture control for the dryer if required should be indicated and; It should also be indicated whether the dryer has been found to be satisfactory for drying wet processed Arabica coffee. These specifications

are necessary for screening the dryers before evaluation. At the end of evaluation, the dryer must be appraised economically and financially to enhance its adoption.

Efficiency in the human resources

The other constraining factor has been on efficiency of the factory operators to implement the drying procedure to the letter. This can also prevent the effective utilization of available labour. This shortcoming has been addressed through regular in-service and field training.

Moisture content of the coffee during drying

To ensure that coffee dries at the required rate throughout, the capability to measure the moisture content particularly from soft black to fully dry status is very necessary. This makes it easy to avoid over drying. Oral measurements by cracking beans with the teeth and accessing the ease of hulling parchment by rubbing a sample between the hands are the conventional means employed to determine whether the coffee has dried fully while use of moisture meters is very limited. However, weighing a known volume of coffee can be used to estimate its water content but its robustness must be proved and any shortcomings charted. One such specific issue relates to shrinkage during water loss. If the particles shrink to a greater degree than the volume of water removed, the packing changes and one could predict a systematic error due to the standard container accommodating increasing amounts of dry matter and a flattening in the relationship between weight loss and water loss as drying occurs. A second potential source of error would lie in any inherent differences in the density of the grains due to seasonal regional or physiological effects. A study to this effect was conducted on different parchment grades arising from density grading in a washing channel.

The relationship between weight and volume was clearly linear though with only a moderately good adherence to the best-fit line. As expected, grade 1 was denser than 2 and grade 2 was denser than lights. However, sometimes grade 2 from one source was denser than grade 1 from another source. If this were a real result and not one due to inaccurate extrapolation, establishing a weight, which deems Kenyan parchment coffee, even grade-by-grade, to be dry would be problematic. Further field-testing of weight of a constant volume of parchment during drying ultimately showed there was a consistent packing error and that there were significant differences depending on source and parchment grade.

Security

In the absence of effective security, the operators can transfer wet coffee to facilities not suited to drying though secure. Since that can have adverse effect on coffee quality, it warrants for provision of proper security of the drying coffee instead of taking such an aspect for granted.

DISCUSSION AND CONCLUSION

Drying coffee should never be covered with Hessian or sisal cloth alone. In hot dry weather, the finished coffee should be removed from the tables while cool. Over drying rather than under drying is preferable, but time should not be wasted deliberately over drying.

The foregoing analysis indicates that the conventional drying tables still remain the commonly used coffee drying technology in Kenya to date. This is much so in the cooperative and the smallholder sector unlike in the estates. However, new and appropriate technologies are still required to supplement the solar drying. This should be prioritized to ensure that the

cited constraints are decimated. In addition to that, the drying table capacity in all the coffee factories should be restored by expedient repair of the damaged ones. Otherwise, their necessary scheduled service and maintenance should be resorted to as required.

There are currently new innovations developed recently in the world towards this end. There is need therefore to sustain the evaluation activities to identify those which can be adopted into the Kenya coffee industry as they are or in a modified form.

Conditioning was introduced; it has been reported, to produce uniform drying though it has evidently become a tool to manage periods of high demand on the drying tables. The danger here is that very wet coffee can be transferred to manually conditioning bins where it will not dry further at all. This can easily happen in coffee factories with limited drying tables since most of the tables have deteriorated because of long lapse of low production, which led to minimal or no usage of such tables with hence no repair or maintenance. As a solution, the manual operated bins should be ventilated. This will require all the factories to electrified and electric fans installed for this purpose.

Finally, the know-how of the factory operators should be sustained through regular training. By so doing, the entire process as well as the existing and any new equipment will be operated efficiently for the improved quality, health and safety of Kenya coffee.

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