

Approach of Improving Coffee Industry in Taiwan-Promote Quality of Coffee Bean by Fermentation

Cheng-Chang Lin, Depart. of Hospitality management, Diwan University, Taiwan

ABSTRACT

Coffee is a typical drink with substantial increasing in global. With the growing popularity of coffee consumption, raw materials of coffee bean are mostly imported and are increased year by year in Taiwan. The study is firstly based on a qualitative research method of an in-depth interview, discussion, field investigation, and analyzing environment of coffee industry in Taiwan to realize the problem. And then, a quantitative research method finds out an approach of fermentation to help development of this industry. This research has achieved the approach to ferment a good quality coffee bean which improves the local bean with the competitive ability with import product.

Keywords: Green coffee bean, Fermentation, Cupping, Reduced sugar

INTRODUCTION

Coffee is a typical drink with substantial increasing in global. With the growing popularity of coffee consumption, raw materials of coffee bean are mostly imported and are increased year by year in Taiwan. This research has achieved the approach to ferment a good quality coffee bean which improves the local bean with the competitive ability with import product. The study is firstly based on a qualitative research method of an in-depth interview, discussion, field investigation, and analyzing environment of coffee industry in Taiwan to realize the problem. And then, a quantitative research method finds out an approach of fermentation to help development of this industry.

Coffee consumption in Taiwan: The coffee bean was imported total 4,238 tones in 1998 but it increased 13,872 tons in 2007 about 3.3 times as much as the past ten years (ICO, 2010). Due to financial crisis growth import was slightly reduced to 11,600 tones in 2008. The product as the main constituents of coffee extract was increased from 3,812 tones in 1998 to 6,779 tons in 2002, and is maintaining about 6,000 tons in recent years. On the whole, coffee-related products were imported 19,283 tons with value about NT dollar 28.2 billion in 2008. The scope of the coffee plant is expanding to 561.0 hectares and produced a total of 452.7 tones of coffee beans in Taiwan in 2007. Observation showing growth trend of consuming, we are expected the planted area continuing to rise in future. As the leisure industry developing prosperous, the demand for coffee is greatly increased to expect local coffee being a Taiwan's new agricultural. The development of coffee industry would be stressed coffee brands, combined with cultural, and tourist resources backed up marketing to attract the public in-depth place of origin, close to and experience with coffee-related activities. And then, it is expected to form a unique coffee culture industry in Taiwan. Following the growing coffee tree, a technology is needed to treat coffee fruit for product of quality and expertise of coffee beans for the local farmer.

INVESTIGATION LOCAL PROCESSING TECHNOLOGY

Coffee is fermented to remove a layer of mucilage from the seed inner integument to which it adheres. Coffee fermentation is conducted for rather different reasons that contribute nutrition, taste, stability, and flavor all of these benefits on raw materials of coffee beans. But, fermentation which is badly conducted can result in disastrous losses in quality. To produce coffee beans, there are three distinctly different coffee processing methods; wet process, dry process, and semi-dry process. In Taiwan, preliminary processing of coffee is once picked red coffee cherries which are immediately processed with wet process. The wet method requires the use of specific equipment and substantial quantities of water. When properly done, it ensures that the intrinsic qualities of the coffee beans are better preserved,

producing a green coffee, this is homogeneous and has few defective beans. Hence, the coffee produced by this method is usually regarded as being of better quality and commands higher prices. The product processes of wet method are sorting and cleaning, pulping, washing, fermentation, washing and drying.

Sorting and Cleaning: Coffee harvesting is normally occurs in the morning since the afternoon and evening is reserved for pulping operations. Given that pulping always takes place in the late afternoon through the evening. Even after careful harvesting, a certain number of partially dried and unripe cherries, as well as some stones and dirt, will be present among the ripe cherries. As in the dry method, preliminary sorting and cleaning of the cherries is usually necessary and should be done as soon as possible after harvesting. This operation is done by washing the cherries in tanks filled with flowing water. Screens may also be used to improve the separation between the ripe and unripe, large and small, cherries.

Pulping: After sorting and cleaning, the pulp is removed from the cherry by a machine which squeezes the cherries between fixed and moving surfaces. The pulp of the fruit is separated from the beans before the drying stage. The flesh and the skin of the fruit are left on one side and the beans, enclosed in their mucilaginous parchment covering, on the other. The clearance between the surfaces is adjusted to avoid damage to the beans. The pulping operation should also be done as soon as possible after harvesting to avoid any deterioration of the fruit, which might affect the quality of the beans. The pulped beans go on to vibrating screens, which separate them from any un-pulped or imperfectly pulped cherries, as well as from any large pieces of pulp that might have passed through with them.

Washing: From the screens, the separated pulped beans then pass through water-washing channels where a further flotation separation takes place before they are sent to the next stage. Because the pulping is done by mechanical means it normally leaves some residual flesh as well as the sticky mucilage adhering to the parchment surrounding the beans. This has to be completely removed to avoid contamination of the coffee beans by products resulting from the degradation of the mucilage.

Fermentation: The newly pulped beans are placed in large fermentation tanks in which the mucilage is broken down by natural enzymes and microbiology until it is dispersible, when it can be washed away (Avallone *et. al.*). The fermentation must be concluded as soon as possible after sufficient mucilage degradation has been accomplished. Unless the fermentation is carefully monitored, the coffee can acquire undesirable, sour flavors. For most coffees mucilage removal takes between 24 and 48 hours. The most important of these conditions is depending on the temperature, thickness of the mucilage layer and concentration of the enzymes and microbiology. The end of the fermentation is assessed by feel, as the parchment surrounding the beans loses its slimy texture and acquires a rougher pebbly feel. This is ascertained by rubbing the parchment between your fingers to note whether the grittiness of the parchment surface can yet be felt.

Washing: The mucilage which covered on pulped bean is a kind of pectin needed to proper degradation to sugar which is contributed a good sweet taste and caramel flavor during toasting coffee bean. But it is usually over fermented to continue degrading sugar to alcoholic and acidic compounds which lead to coffee beans not only lost sweet taste also contaminated with acidic flavors and odors. After fermentation, they are required thoroughly washed with large amount clean water in tanks with special washing machines. The coffee bean is releasing part of component or nutrition during washing with strong power water.

Drying: The wet parchment coffee bean at this stage consists of approximately 57% moisture. It is needed to reduce the moisture as soon as possible to an optimum 12.5% the parchment coffee either in the sun, in a mechanical dryer, or by a combination of the two. The sun-drying is done on extensive flat concrete or brick areas, known as patios, or on tables made of fine-mesh wire netting. The beans are laid out in a layer of 2 to 10 cm, and turned frequently to ensure even drying. Sun-drying should take from 8 to 10 days, depending upon ambient temperature and humidity. Coffee dries more quickly if raised on tables because of the upward draught of warm air. The use of hot-air drying machines becomes necessary to speed up the process in large plantations where, at the peak of the harvesting period, there might be much more coffee than can be effectively dried on the terraces. However, the process must be carefully controlled to achieve satisfactory and economical drying without any damage to quality.

WHAT IS PROBLEMS TREATMENT OF CURRENT COFFEE?

The main problem is come from improper fermentation. Pulped coffee contains about 17% of sugar, another 1% of pectin substances, and 13% protein. However, the conditions, they provide exceptionally useful nutrition toward wild microbial flora. Because the fermentation process is happened in the fruit-inhabiting community without inoculating microbiology, it takes 24~48 hours to digest the residual pulp. The temperature of either of these processes is scarcely raised over 50°C above ambient temperature reflecting the lack of oxygen diffusion to the heart of the mass. The fresh mucilage has pH original about 6.5 falling to a minimum of about 3.1 to 3.3. Because improper fermentation, the badly odors coffee beans are required washing out with substantial amounts of water in tanks with machines (18 kg water for 1 kg coffee). Even though, which results in the coffee bean acquires sour flavors and evil odors. Investigation local processing technology of coffee beans is deficient which is caused lower quality of coffee beans and weakness of international competitiveness in Taiwan now. From a taste quality point of view, the fermentation steps and operations are required conformance to certain criteria.

Following the growing coffee tree, a technology is needed to treat coffee fruit for product of quality and expertise of coffee beans for the local farmer. But, investigation local processing technology of coffee beans is deficient which is caused lower quality of coffee beans and weakness of international competitiveness in Taiwan now.

METHODS

Coffee cherries (*Coffea arabica*) were hand-picked at the mature stage in farms from the Taitung County, Taiwan. Skin and pulp were mechanically eliminated and de-pulped beans were then prepared as sample for fermentation. Samples were harvested from four different farms locations at the county.

Coffee Cherry

Coffee cherry must be treated in 24 h after harvested. The present work is a wet processing. The fruit was mechanically pulped to take off skin and green coffee bean was fermented with adding enzyme1, enzyme2, *Leuconostoc mesenteroides*, *Kluyveromyces marxianus*, *Kluyveromyces lactis*, *Rhizopus oryzae*, *Aspergillus niger*, and *Aspergillus niger* with enzyme1 (Bluemke et. al., Bramorski et. al., Christen et. al., Collins., Jackels et. al., Janssens et. al., 1992, 1988., Medeiros et., al., 2006, 2003, 2001, 2000, Soares et., al., US Patent 4867992). The required fermentation time, reduced sugar (%), and pH was determined when mucilage of green coffee bean was removed. And then, green coffee bean without washing was directly dried to moisture content 12% by sun.

Determination of Proper Fermentation

Green coffee bean was fermented by mixture of *Aspergillus niger* with enzyme1. The characteristics of the final fermentation as reduced sugar (%) and pH were determined during processing of fermenting time from 1 h to 12 h. Four samples of cherries were monitored its reduced sugar (%) when it fermented at pH 4.6.

Evaluation of Coffee Cupping

Green coffee bean was roasted to medium with a small roaster and then cupping by trained and experience teacher. A sample of 12 g medium roasted coffee was finely ground and placed in a glass cup. The aroma of the ground coffee was smelled and then the brew was made by adding freshly boiled water. The aroma of the crust and broken crust were sampled. Following crust removed with stainless steel spoons, the coffee was tasted by aspiration into the mouth and nose. Scores were recorded for aroma, body, acidity, flavor, after-taste and balance according SCAA (Sweet Maria's home coffee roasting, The Caves). The total scores were tabulated on a 100 point scale where 90 ~ 100 is excellent, 80 ~ 90, very good; 70~80, commercial grade, and below 70, poor or damaged. Statistical analysis was carried out using SPSS (version 14.0 for Windows 2005). The pH of brewed coffee was measured by pH meter (model)

RESULT

Effect of Fermentations and Time on Green Coffee Bean

In a pre-test, *Rhizopus oryzae* and *Aspergillus niger* were able to degrade part of mucilage and pectin of coffee cherry at 24 h fermentation to have reduced sugar 10.65% and 11.38% (Table 1). *Leuconostoc mesenteroides*, *Kluyveromyces marxianus*, and *Kluyveromyces lactis* were found a different capability. Cellulase was found with reduced sugar 9.87% at 30 m. In an advance research, fermentation by cellulase mixed with *Aspergillus niger* produced 14.15% reduced sugar and pH 4.8 at 30 m, and without slipping feeling green coffee bean by hand.

The component of cherry is about 12% protein and polysaccharides. *A. niger* or enzyme fermented or degrade them into small compounds such as peptides, amino acid, and sugar can be absorbed or permeatable through parchment of green coffee bean.

All of this is finished by way of without water cleaning the bean. The predict efficiency is to promote the quality of native coffee, to help to dissolve the processing problem to control the fermentation for preventing bacteria growth to worse fermentation, and to less the amount of waste water from 18 kg ~10 kg of 1 kg coffee.

Table 1: Effect of enzyme and fungi on different fermentations and time on reduced sugar and pH

Condition	Time	Reduced sugar (%)	pH	Mucilage
Enz1	20 m	9.87	5.0	+++
Enz2	24 h	-	-	-
F1	24 h	10.65	5.0	++
F2	24 h	11.38	5.1	++
Y1	24 h	-	-	-
Y2	24 h	-	-	-
L1	24 h	-	-	-
Enz1+F2	30 m	14.15	4.8	+++

L1: *Leuconostoc mesenteroides*

Y1: *Kluyveromyces marxianus*

Y2: *Kluyveromyces lactis*

F1: *Rhizopus oryzae*

F2: *Aspergillus niger*

Determination of Proper Fermentation

The green coffee bean affects on quality of brew coffee. Determination of proper fermentation of coffee cherry is a key point. Once green coffee bean with well fermentation must be completely removed mucilage without slipping feeling green coffee bean by hand. According as chemical reaction during fermentation, reduced sugar initially increases from 7.55% to the highest level 14.78% at 2 h and maintaining the level until at 4 h then gradually decreasing to 13.51% at 12 h (Figure 1). At the relative point, pH is changed from beginning 6.33 sharply decreasing to 4.62 at 1 h, and down to 4.55 at 2 h, to 3.87 at 12 h. It is reasonable the reduced sugar is derivative compound from degrading mucilage or pectin by yeast, fungi, and bacteria. Acetic acid bacteria and lactic acid bacteria are continually fermenting reduced sugar to produce alcohol, acetic acid, and lactic acid which lead to lower pH. To compare with the level of reduced sugar and pH, the highest reduced sugar (14.78%) is benefit for formation of aroma and taste but at this point pH is 4.25 which is stronger acidity than 4.62 (reduced sugar 14.36%). Because stronger acidity is defect for coffee taste and longer time causes higher cost. Odors were formed at 10 h. We suggest that the proper fermentation is determined by pH 4.6.

During fermentation, green coffee bean was maintaining at same temperature and aeration leading to decrease weight 1~2% a day. In the field research, coffee cherry contains wide range of sugar and protein depending on its species, weather, ripe degree, management, soil, and sunlight. In this work, green coffee beans from four farms have initially content of reduced sugar 7.55%, 7.98%, 6.59%, and 8.32% respectively (Table 2). At the end of fermentation as pH at 4.6, reduced sugars of four beans of fermentation are individually 14.36% (contrast 10.68%), 15.52% (contrast 10.49%), 14.21% (contrast 10.18%), and 15.87% (contrast 10.07%). At this moment, the green coffee bean has removed its covered mucilage and smelling with fruit flavor. After roasted, green coffee performs condensed caramel,

richer flavor and taste sweetness and bitterness with the sequence of reduced sugar 15.87%, 15.52%, 14.36%, and 14.21%. Sugar and amino acid are precursors to drive caramelization process called Maillard reaction which is progressing during roasting to produce brownish, bitter-sweet glycosylamine and melanoidins to donate coffee a favor taste. Finally, the product is taste balanced performance, sticky, thick, and mellow. Under different condition, it is needed to control a proper fermentation. The contrast coffee bean was conducted by natural fermentation of 24 h to harvest reduced sugar 10.07%~10.68%, pH 3.91~4.12. The over fermentation can lead lower acidity or odors decrease its quality.

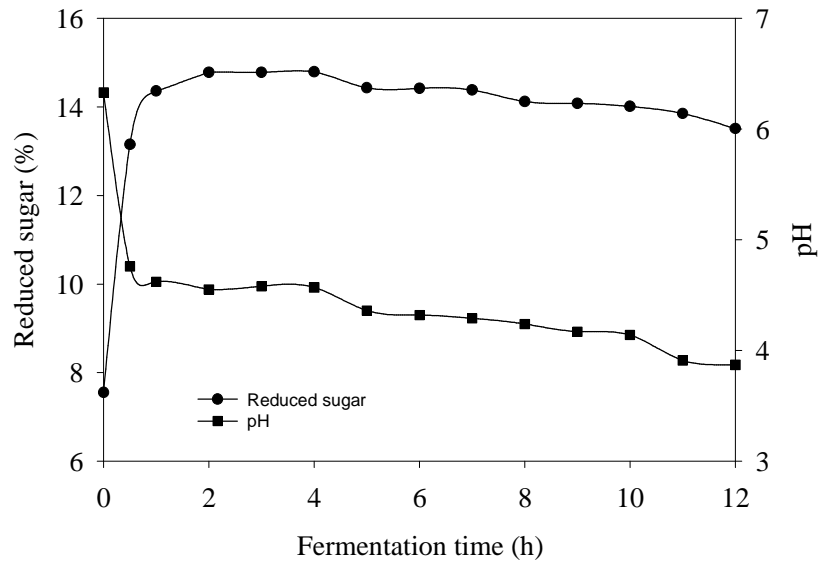


Figure 1: Characteristics of green coffee beans fermenting at different time

Table 2: Reduced sugar and pH of green coffee bean after fermentation by enzyme mixed with *Aspergillus niger*

S	Sugar _{In} (%)	Sugar _{Fer fi} (%)	pH _{Fer fi}	Sugar _{Cos fi} (%)	pH _{Cos fi}
S1	7.55	14.36	4.62	10.68	4.02
S2	7.98	15.52	4.64	10.49	3.97
S3	6.59	14.21	4.64	10.18	4.12
S4	8.32	15.87	4.61	10.07	3.91

In: Initial
 Fer fi: at final of fermentation
 Cos fi: at final of contrast

Quality Evaluation by Cupping

Green coffee bean was dried to approximately 12% moisture by sun and used for husking, roasting, and cupping. Average cupping score, green coffee bean fermenting at 1 h performed 82.78 significantly better than its controlled test with natural wet fermentation at 24 h 76.17 (Table 3). The higher caramel tastes at fermenting 1 h, 2 h, and 3 h are reasonable contributed by higher level reduced sugar during toasted coffee bean but it is decreased at 6 h as same as decreased reduced sugar (Figure 1). The complexity reaction such as Strecker degradation, degradation of amino acids, trigonelline, sugar, phenolic acids, quinic acid, and lipid during roasting which relate to ferment is needed to be advance examination.

Table 3: Effect of fermented time on cupping

Time (h)	Score	SD	Taste ¹
0.5	79.46	3.2	Lower caramel tastes and weaker acidity
1	82.78	2.9	Strong caramel tastes and acidity increase +
2	83.37	3.1	Strong caramel tastes and acidity increase ++
4	83.78	3.7	Strong caramel tastes and acidity increase +++

6	81.46	4.0	Strong caramel tastes and acidity increase ++++
24 ^c	76.17	3.7	Lower caramel tastes and stronger acidity

¹: Roasted temperature 217 °C, 19 m °

^c: Controlled test with natural wet fermentation 24 h.

+: With increasing level.

CONCLUSION

Fermentation was operated by mixture of *Aspergillus niger* and enzyme. The benefits of this fermentation are:

1. The fermented time is shortening to 1 h from natural fermentation 24 h. It is very economic way for small farmer to finish treatment of coffee cherry per day harvest.
2. The product of green coffee bean produces higher reduced sugar (from 7.98 to 15.52) and weaker acidity (pH from 3.07 to 4.64).
3. Coffee cupping with the result of taste more sweet, full body, pure and with caramel flavor.
4. The amount of waste water less from 10~18 kg to 1 kg for 1 kg green coffee bean.

Therefore, the fermentation is an efficient way to promote the quality of native coffee, to help to dissolve the processing problem to control the fermentation for preventing bacteria growth to worse fermentation.

REFERENCES

- Avallone S., Guyot B., Brillouet J.M., Olguin E., Guiraud J.P., (2001), Microbiological and Biochemical Study of Coffee Fermentation, Current Microbiology, 42: 252~256.
- Blumke W., Schrader J., (2001), Integrated bioprocess for enhanced production of natural flavors and fragrances by *Ceratocystis moniliformis*, Biomol. Eng., 17: 137~142.
- Bramorski A., Christen P., Ramirez M., Soccol Revah C.R., S., (1998), Production of volatile compounds by the fungus *Rhizopus oryzae* during solid state cultivation on tropical agroindustrial substrates, Biotechnol. Lett., 203: 59~362.
- Christen P., Meza J.C., Revah S., (1997), Fruity aroma production in solid state fermentation by *Ceratocystis fimbriata*: Influence of the substrate type and the presence of precursors, Mycol. Res. 101: 911~919.
- Collins, E. B., (1972), Biosynthesis of flavor compounds by microorganisms, J. Dairy Sci., 55(7): 1022~1028.
- Jackels S.C., Jackels C.F., (2005), Characterization of the coffee mucilage fermentation process using chemical indicators: a field study in Nicaragua. J. Food Sci., 70: C321-C325.
- Janssens L., De-Poorter H.L., Demey L., Vandamme E.J., Schamp N.M., (1992), Production of flavours by microorganisms, Process Biochem. 27: 195~215.
- Janssens L., De-Poorter H.L. Demey, L., Vandamme E.J., Schamp N.M., (1988), Fruity flavours by fermentation, Med. Fac. Landbouww. Rijksuniv. Gent, 53: 2071~2077.
- Medeiros A.B.P., Pandey A., Vandenberghe L.P.S., Pastore G.M., Soccol C.R., (2006), Production and recovery of aroma compounds produced by solid-state fermentation using different adsorbents, aroma compounds produced by fermentation, Food Technol. Biotechnol. 44 (1): 47~51.
- Medeiros A.B.P., Christen P., Roussos S., Gern J.C., Soccol C.R., (2003), Coffee residues as substrates for aroma production by *Ceratocystis fimbriata* in solid-state fermentation, Braz. J. Microbiol., 34: 245~248.
- Medeiros A.B.P., Pandey A., Christen P., Freitas R.J.S., Fontoura P.S.G., Soccol C.R., (2001), Aroma compounds produced by *Kluyveromyces marxianus* in solid-state fermentation on packed bed column bioreactor, World J. Microbiol. Biotechnol., 17: 67~771.
- Medeiros A.B.P., Pandey A., Freitas R.J.S., Christen P., Soccol C. R., (2000), Optimization of the production of aroma compounds by *Kluyveromyces marxianus* in solid-state fermentation using factorial design and response surface methodology, Biochem Engi J., 6(1): 33~39.
- Soares M., Christen P., Pande A. y, Soccol C.R., (2000), Fruity flavour production by *Ceratocystis fimbriata* grown on coffee husk in solid-state fermentation, Process Biochem. 35: 857~861.
- US Patent 4867992, Natural coffee flavor by fermentation, US Patent Issued on September 19, 1989.
- ICO., International Coffee Organization, 2010, 3,10. http://tw.myblog.yahoo.com/jw!gGk_TCGBxzkQso4M2w-/article?mid=393.
- Sweet Maria's home coffee roasting, <http://www.sweetmarias.com/index.php> , 2009,1,12.
- The Caves: Flavor Wheels of the World, <http://www.eblong.com/zarf/cave/flavorwheel.html>, 2009,1,12.