Comparative Study Analysis Of The Effects Of Different Types Of Demucilagination On The Physical And Organoleptic Quality Of Green And Roasted Robusta Coffee (Coffea Canephora Var. Robusta)

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***Abstract*—After harvesting, fresh cherries of robusta coffee were sorted and grouped in samples of 10 l, and then submitted to 6 different demucilagination treatments in a one-way completely randomized experimental design with 4 replications. Demucilagination, followed or not by soaking in water was applied as natural fermentation, chemical fermentation using 0,1N sodium hydroxide, and enzymatic fermentation, with a commercial enzyme. The drying processing served as control treatment. The pulped, fermented, parchment-free or hulled coffee were checked for quality appreciation on yield in green coffee, occurrence of insect damaged and other types of defective beans, and water content; the roasted coffee quality was evaluated on weight loss, swelling, water content and organoleptic characteristics. Data analysis was performed using MSTAT software and means were separated with Duncan's multiple range test method. Results showed significantly higher (p<0,05) yields in green coffee regardless of the fermentation type, in comparison with the dry method. Drying processing lead to the significantly (p<0,05) higher proportion (82,2%) of insect-damaged and other defective beans due the delay involved in pulp removal. Fermentation was shown to promote a lower water content (11,83%) in green coffee, as opposed to that recorded with dry process (13,7%), which also lead to the highest humidity content ((5%) in roasted coffee. The use of an enzyme for mucilage removal with or without water favored a significant (p< 0,05) drop of 25,5% in weight loss in roasted coffee. Chemical treatment using sodium hydroxide, in wet or dry conditions brought a significant (p <0,05) increase in swelling of beans (17%) during roasting. The type of treatment had no influence on the bitterness of coffee taste, and coffee from drying process had a more astringent and acid taste and was therefore less preferred.**

Keywords—Robusta coffee, demucilagination, roasting, green coffee, swelling, aroma,quality.

1. INTRODUCTION

Coffee bears a reliable economical importance in Cameroon and other African world wide countries where it is cultivated at a higher scale (Anonymous, 1892). In 1979, it provided about 26% in value among exported crops in Cameroon, and 31% in Ivory Coast and 15% in Brazil (Anonymous, 1982). Robusta coffee contributes to about 77% in coffee production and about 62,64% in coffee exportation. Most of coffee robusta is processed through the dry method in the world (Coste, 1968). In Cameroon, robusta coffee is similarly treated. However, drying of coffee, as initial step in that processing method, is a complexe operation, very often including some hazardous and uncontrolled unknown factors (temperature, hygrometry, microbial flore, chemical and enzymatic reactions) which affect coffee final quality (Wilbaux, 1964; Valencia, 2007; and Djossou and al., 2O11). Vincent, (1968) indicates that high humidity and high temperature conditions favor the development of Aspergillus flavus and equally deterioration agents of physical aspects of coffee bean as well, in the fleshy and sugary tissue of coffee pulp (Avallone and al., 2000; Knopp and al., 2006). The lack of cleaning for removal of coffee residues and the lack of covering of cherries in drying areas of coffee cherries creates a great opportunity for microorganism growth on exoderm and endoderm of coffee fruits, leading to the development of an undesirable taste in green coffee. Time spent in drying coffee cherries containing a high water proportion of 61% is very long (4 weeks) as opposed to that of parchment coffee (10-15 days).w ith a lower water content of 45% (Wilbaux, 1956; Coste, 1959).

The long exposure of coffee cherries to uncontrolled weather conditions increases the risks of mould infection and development in the products (Sivetz and Desrosier,1979). The wet method offers an alternative option for robusta coffee processing while improving coffee product quality. This method ensures the removal of coffee pulp and thus discarding part or total of microflore negative impact, due to the short drying period (Sivetz and Foote, 1963;Shitage and al., 2014) . According to Wilbaux (1956), and Santos (1973), the wet method improves the physical and organoleptic quality of coffee. Different forms of demucilagination including natural fermentation in water, chemical and enzymatic demucilagination, are currently used with satisfactory results (Wilbaux, 1956; Coste, 1959; Rolz,1981) Sodium hydroxide (NaOH) as chemical agent, provides a rapid demucilagintion in 10 mn, along with improvement of coffee quality, when followed by dipping in water (Sivetz and Desrosier, 1979; Wootton, 1963, Petnga, 1983). However, the causticity of NaOH compromises its use The objective of this research is to evaluate the impact of different forms demucilagination on robusta green and roasted coffee.

2. MATERIAL AND METHODS

Robusta coffee fresh coffee cherries were harvested at 3 months of maturity, in IRAD experimental plots of Nkolbisson near Yaounde, in Cameroon, and were grouped in sample units of 10 l each. Cherries from 24 of these samples were pulped and were attributed the 7 selected wet method. Demucilagination effect was tested through 6 forms of that coffee wet processing type: 1) natural fermentation with and without dipping in water, 2) chemical fermentation with no water,3) chemical fermentation using NaOH, with and without water, 4) enzymatic fermentation followed or no by dipping in water. In natural fermentation followed by dipping in water, a 10 l bucket containing pulped coffee was filled with water, then the mixture in the bucket was washed after 17 h of fermentation and dried. In natural fermentation with no water dipping, holes were made on the bucket to allow elimination of any water in that container, which was thereafter filled with pulped coffee and left for 17h of fermentation, before washing and drying.

For chemical fermentation in water, 10 l of pulped coffee were for 10 mn blended with 0,1 N NaOH solution followed with washing using abundant water and then dipped water for 6 h as parchment coffee, and sun dried. In the option with no water dipping, parchment coffee was sun dried directly following washing. In enzymatic fermentation associated with dipping in water, pulped coffee was mingled with 4 l of water solution of 2g a commercial prepared enzyme product by SANDOZ, cofepec, which was previously mixed with 200 ml of water. The mixture was then thoroughly homogenized and left for 17h dipping period, and coffee was then washed and sun dried. The alternative form without dipping of that treatment consisted of mixing and homogenizing of coffee cherries with 2 g of dry cofepec powder , after which coffee was dipped for 17 h, then washed and exposed to sun for drying.

The dry processing method involved the sun drying of freshly harvested coffee cherries, which were frequently turned over. Parchment coffee obtained from the different forms of the humid processing method was dried during 2 weeks whereas coffee cherries took 4 weeks to dry into dry cherries. Following sun exposure, parchment and hull removal were done. The quality of green coffee obtained from these operations was appreciated with focus on physical and commercial aspects of green and roasted coffee: 1) Yield in green coffee from hulling and parchment removal, 2) proportion on defective beans (insects-attacked; broken beans, and mouldy and undesirable beans), 3) water content in green coffee,

The yield green coffee was calculated as percentage of hulled or parchment-free coffee bean hulling or parchment removal operation, after drying of 500 g of dry cherries or parchment coffee. The defective coffee was the percentage of defective beans (insect–attacked beans, broken beans, mouldy and undersirable beans), after identification, counting and weighing of 300 g of hulled or parchment –free coffee beans. Water content was evaluated by weighing of coffee beans before and after two successive stays of 16 h ±15 mn and 4h ±15mn respectively in an oven at 103± 2°C, with a period of 15 h for cooling in a dessicator between the 2 stays. Weight loss in roasted coffee was evaluated by double weighing before and after roasting in a roaster heated to 240 °C. Swelling index of roasted coffee was obtained in measuring the volume of coffee beans before and after roasting, with the roaster temperature brought gradually to 240 °C (Marija and al., 2012).

Water content of the roasted coffee was calculated by weighing of ground roasted coffee before and after a stay of 16 h ±15mn in an oven under 103 ± 2 °C. The organoleptic quality of coffee was evaluated through the triangular test (Watts et al.,1991), using the following judgment specifications: 1) The unique sample, different from the others, 2) The high bitterness sample(s), 3) The high acidity sample(s), 4) The high aroma sample(s), and 6) The high preference sample(s). The angular transformation was done for data expressed in percentages, and statistical analysis was proceed through ANOVA, using MSTAT with Fisher test at 5% level of significance, and mean separation was carried out when significant differences were detected between treatment effects.

3. RESULTS

The yield in green coffee, regardless of the type and form of demucilagination used, was significantly higher ($p<0.05$) in comparison with that obtained with the dry method (Table 1). No significant difference ($p>0.05$) was recorded among samples of products from he different types and forms of fermentation. Insect-attacked and undersirable beans were the most ly occurring defect types. Drying of coffee cherries lead to the obtention of more defective beans than drying of fermented and pulped coffee. The use of the commercial enzyme for mucilage removal has reduced more defective coffee as compared to that obtained with sodium hydroxide. Besides, enzymatic is faster and more efficient than natural fermentation. Among the types of mucilage disintegrating methods, water dipping yielded no significant change ($p>0.05$).

The coffee borers constitute the major cause of insect-attacked beans. Coffee borers damaged coffee was significantly higher ($p<0.05$) when coffee was processed by the dry method. Also, the type of fermentation had no significant difference regarding insect attacks on coffee bean, and no significant impact ($p>0.05$) on undesirable beans formation. Different treatment effects on coffee samples exposed to the same drying conditions led to significantly different ($p<0.05$) coffee bean water contents. The highest water contents were that of coffee from dry processing or from fermentation in water.

The commercial enzyme favored a higher water content in green coffee than the use of sodium hydroxide did, in fermentation with or without water, Dipping in water induced a significant increase ($p<0.05$) in water content of coffee grain, whereas the duration of dipping had no significant influence recorded.

Table 1 Effects of the type of demucilagination on yield in green coffee (gc), formation of defective beans (db), insect-damaged bean (iab), water content in green bean (wcg) weight loss in roasted coffee (wlr), swelling index in roasted coffee (swr), and water content in roasted coffee (wcr)

Type of demucila-gination	gc (% wt)	db (% wt)	iab (% wt)	wcg (% wt)	wlr (% wt)	swr (% vol)	wcr (% wt)
DP[(1)]	51,10$^{a(y)}$	39,00$^{a\,(z)}$	31,00	13,70^{a}	23,50^{a}	70,30^{a}	05,50^{a}
CF-H_2O	85,10^{b}	49,60^{ab}	07,00^{b}	10,20^{c}	15,10^{c}	84,10^{b}	02,72^{b}
CF+H_2O	85,50^{b}	57,30^{bc}	09,20^{b}	12,20^{b}	12,50^{ab}	84,80^{b}	03,12^{b}
EF+H_2O	85,60^{b}	62,00^{cd}	10,00^{b}	12,30^{b}	18,90^{b}	84,40^{ab}	02,65^{b}
NF-H_2O	85,80^{b}	69,80^{d}	10,30^{a}	12,10^{b}	15,50^{c}	74,80^{a}	02,69^{b}
NF+H_2O	86,00^{b}	70,40^{de}	08,90^{b}	12,80^{b}	16,20^{b}	77,50^{a}	02,95^{b}
EF-H_2O	86,20^{b}	82,20^{e}	09,90^{b}	10,50^{c}	16,10^{bc}	77,40^{a}	02,74^{b}

DP: Dry processing;
CF-H_2O: Chemical fermentation with no dipping in water,
CF+H_2O: Chemical fermentation followed with dipping in water;
EF+H_2O: Enzymatic fermentation in water;
NF-H_2O: Natural fermentation without water;
NF+H_2O: Natural fermentation in water;
EF-H_2O: Enzymatic fermentation without water.
(y) : Data are means of 4 observations
(z): Means within treatment not followed by the same letter are significantly different at 50% level by Duncan's multiple range test.

Water content of roasted coffee is not influenced by the type of fermentation, Instead, any fermentation form brought a significant reduction ($p<0.05$) in humidity content of roasted coffee, in comparison with the dry method. During roasting, water content increased in coffee as temperatures increased (Fig.1). As observed, beyond 200 degree C, coffee from dry method lost water faster.

The dry method and the use of sodium hydroxide, followed by dipping in water brought a significant increase in weight loss in roasted coffee. The condition of fermentation had no significant effect ($p>0.05$) on weight loss in roasted coffee beans, except when using cofepec enzyme as well as in natural fermentation. In addition, the use of sodium hydroxide followed with no dipping produced a significant reduction ($p<0.05$) in weight loss of coffee from roasting. Increasing roasting temperatures was accompanied by an increasing weight loss in coffee beans (Fig.2), although at a constant rate for coffee from dry method.

The swelling index recorded on roasted coffee grains showed no significant difference (p>0.05) between the dry and the wet methods of coffee processing. However, enzymatic fermentation associated with dipping and that using sodium hydroxide with no dipping produced roasted coffee with higher swelling index. Swelling increased as roasting temperatures increased (Fig 3). Roasting induced a faster in swelling for chemical fermentation that was reduced above 200°C, as opposed to the constant rate recorded in that physical process with the other treatments.

Significant differences were detected (at different levels of significance) between coffee samples by panelists between coffee samples from dry method and that from natural fermentation with dipping (Table 2). The bitterness of coffee taste was influenced by the type of treatment. However, coffee from dry processing had a more acid and astringent taste.

Table 2. Number of panelists with positive opinion on the observed organoleptic characteristics of the coffee beverage and level of significance for differences detected between records.

N° of compared samples	Number of positive records on compared samples					
	Diffe-rence	Bitter-ness	Astrin-gence	Acidity	Arome	Preferenc
DP/ NF+H_2O (1)	6/9 S=0,95(y) NF+H_2O# DP	4/6 NS	5/6 S=0,89 DP>NF+H_2O	5/6 S=0,95 DP>NF+H_2O	5/6 S=0,95 NF+H_2O>DP	5/6 S=0,95 NF+H_2O>I
NF+H_2O/ NF-H_2O	3/5 NS(z)	-	-	-	-	-
NF+H_2O/ CF-H_2O	3/9 NS	-	-	-	-	-
NF+H_2O/ CF+H_2O	4/9 NS	-	-	-	-	-
NF+H_2O/ EF-H_2O	2/7 NS	-	-	-	-	-
NF-H_2O/ EF+H_2O	3/9 NS	-	-	-	-	-

DP: Dry processing;
NF+ H_2O: Natural fermentation with water;
NF-H_2O: Natural fermentation without water;
CF-H_2O: Chemical fermentation without water;
CF+H_2O: Chemical fermentation with water;
EF-H_2O: Enzymatic fermentation without water;
EF+H_2O: Enzymatic fermentation with water

(y): S: level of significance in the difference detected between records

(z): NS: Difference not significant.

4. DISCUSSION

The wet method of processing improved the yield in green coffee. The poor yield obtained with the dry method was predictable since the physical change to that coffee product reflects the percentage weight loss resulting from hull and parchment removal , with the hulls having a higher density than parchment (Lower and al., 2008; Nathsubedi, 2011; Shitage and al. 2014). This reveals the bulk effect of coffee hull as well as the impact of prolonged drying on green coffee production. Moreover, the dry processing favors the development of intrinsic abnormalities in treated coffee beans whereas the wet method causes defects during processing stages. The proportion of defective coffee could be higher if sorting by floatation, to discard immature or dry coffee cherries and sprigs was not done. The noticeable presence of insect-attacked beans in coffee from dry method indicates the role of coffee pulp as ideal host for insects causing damaging actions on coffee during drying, mostly if process time of that operation is prolonged (Shitage and al., 2014). It is then to admit that pulped coffee from wet processing is less susceptible to insect attacks and damages.

The higher water content above the standard level of 12% in green coffee from dry processing or from fermentation associated with dipping indicates the slow rate involved in the drying of coffee using these ptions due to the presence of a highly humid pulp hat gets dry into hull (Wilbaux, 1964;Vincent, 1968) . his might also be caused by too wet beans resulting rom the dipping practice, which confirms the impact f these treatments on water content of coffee beans. n general, the dry process produces the same results s the wet method during roasting, but some haracteristics of green coffee are shown with a pecific influence on roasting quality (Vincent et al., 970; Sivetz and Desrosier, 1979). Because its high vater content, green coffee from drying method or rom fermentation followed with drying may need igher temperatures in roasting, to drop to a reduced cceptable humidity content level. Consecutif to the rogressive water content loss recorded during oasrting, and in addition to formation of gaseous products, weight loss increased with time but at stable rate for coffee from dry process and fermentation with dipping in water.

The various types of fermentation exhibit a beneficial effect in improving the physical aspects of robusta green coffee (Wootton, 1963; Djossou and al., 2011; Evangelista and al., 2014). For a better visual appearance of coffee beans fermentation using NaOH or enzyme substance is preferable (Wootton, 1963; Robinson, 1964; Sivetz and Desrosier, 1979, Petnga, 1983; Valencia, 2007, Evangelista and al., 2014). The effect of NaOH shortens the time of fermentation, but this practice infortunately involves accident risks, due to the causticity of sodium hydroxide.. Therefore its utilization should be with great care and a systematic follow up. The use of an catalyst, currently in practice with positive results on arabica coffee (Valencia, 2007),is innovating in the fermentation of robusta coffee. It is therefore expected that with its activating and catalyzing impact, it will promote a rapid fermentation process, mostly in case of an important mass of coffee to ferment (Ehlers, 1981) or when the fermentation is slowed by some other factors. In addition cofepec as enzyme substance is advantageous because it has no toxicity.

The negative characteristics detected through the panel test are mostly brought about by insect-attacked and other defective beans as well, highly present in coffee from dry method. In contrast, fermentation favors the development of a more pleasant aroma in roasted beans and it is therefore preferred compared to drying process (Vincent et al., 1970; Petnga, 1983; Djossou and al., 2011; Evangelista and al;, 2014). Moreover, neither the type nor the form of fermentation exert an influence in the quality of coffee beverage. This stresses the necessity of elimination without delay of the coffee pulp which, according to Sivetz and Desrosier (1979), Lower and al.(2008), Nathsubedi (2011), and Mabbet t (2013), constitutes a favorable medium for chemical and biochemical reactions affecting physical as well as organoleptic quality of coffee .

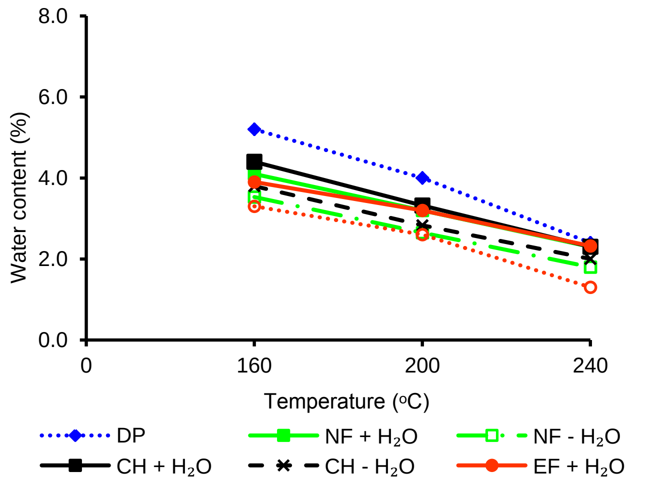

Figure 1 Effects of demucilagination treatments on water content of coffee beans during roasting. Data are means of 4 replicates.

DP: Dry processing;
NF+ H_2O: Natural fermentation with water;
NF-H_2O: Natural fermentation without water;
CF-H_2O: Chemical fermentation without water;
CF+H_2O: Chemical fermentation with water;
EF-H_2O: Enzymatic fermentation without water;
EF+H_2O: Enzymatic fermentation with water.

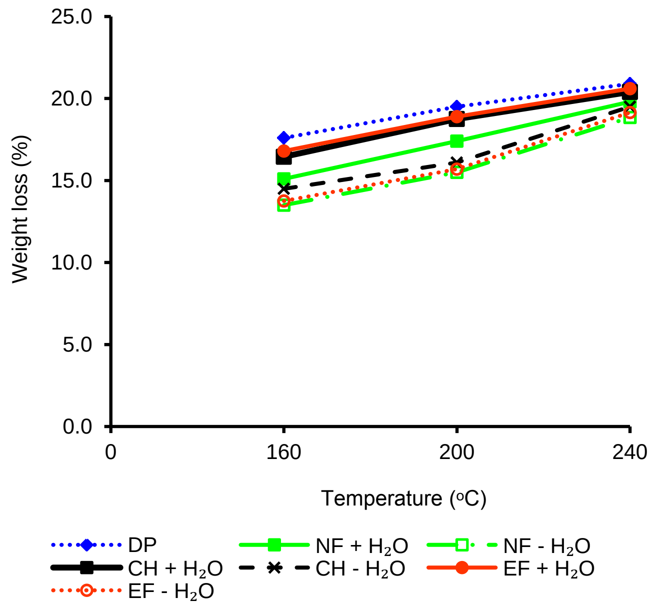

Figure 2 Influence of demucilagination treatments on weight loss in coffee during roasting. Data are means of 4 replicates.

DP: Dry processing;
NF+ H_2O: Natural fermentation with water;
NF-H_2O: Natural fermentation without water;
CF-H_2O: Chemical fermentation without water;
CF+H_2O: Chemical fermentation with water;
EF-H_2O: Enzymatic fermentation without water;
EF+H_2O: Enzymatic fermentation with water

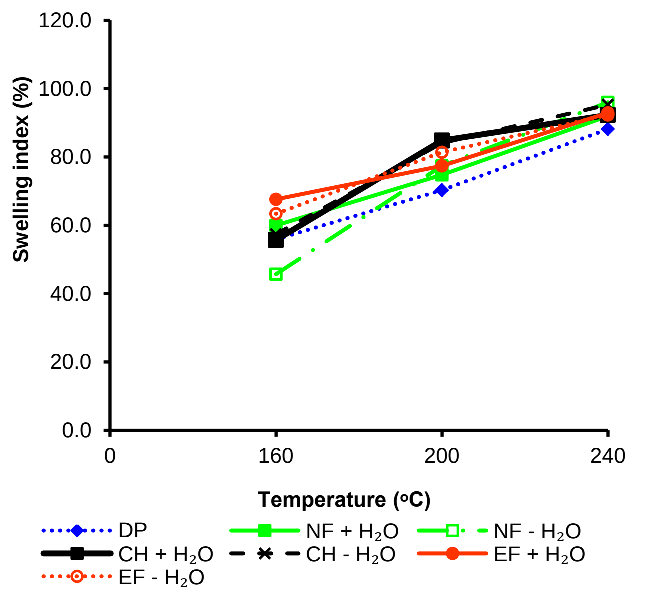

Figure 3 Effects of demucilagination treatments on swelling of coffee beans during roasting. Data are means of 4 replicates.

DP: Dry processing;
NF+ H_2O: Natural fermentation with water;
NF-H_2O: Natural fermentation without water;
CF-H_2O: Chemical fermentation without water;
CF+H_2O: Chemical fermentation with water;
EF-H_2O: Enzymatic fermentation without water;
EF+H_2O: Enzymatic fermentation with water.

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