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RESEARCH ARTICLE

EVALUATION OF CHANGES IN BIOCHEMICAL PARAMETERS OF BANANA (MUSA SPP.) STORED IN POLYPROPYLENE PACKAGINGS.

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Abstract

This study was carried out to evaluate the effect of polypropylene packaging on biochemical parameters of plantain. Two varieties of banana (*French 2* and *Corne 1)* harvested at 70 and 75 days after floral apparition have been stored at 25 °C in 0.235 and 0.303 mm thick polypropylene (PP) packaged. Biochemical characteristics such as pH, titratable acidity, ripening stage, moisture content, ash, reducing sugars and starch content were determined. The results showed that Polypropylene packaging stabilized the biochemical characteristics of plantain. The result about *French 2* indicated stability of parameters between the 12^{th} and 14^{th} day of storage in the bags of 0.235 mm thickness and 18^{th} and 20^{th} day of storage in the bags of 0.303 mm thickness. However, for *Corne 1* variety, the parameters were stable between 10^{th} and 12^{th} days of storage and 16^{th} and 18^{th} days respectively in packages of thickness 0.235 and 0.303mm. Significant differences were not observed for the same treatment at maturity levels of 70^{th} and 75^{th} days. The stability time of the physicochemical characteristics of *French 2* variety is significantly longer.

Introduction:-

Plantain is one of the main food resources in Ivory Coast, and it has a high level of local consumption (Lassoudière, 1973). Post harvest losses a major problem limiting the production of plantain and banana in Africa due to unavailability of established storage conditions that canguarantee longer shelf life (Wills, *et al*., 1989). Annual production of plantain in Ivory Coast is estimated at 1.6 million tons, ranking it third in this country after yam and rice (Ducroquet, 2002; FAO, 2009). During ripening the colour of plantain changes from dark green to bright yellow, due to the degradation of chlorophyll structure, which gradually unmasks the carotenoid pigments present in the fruit (Robinson, 1996). Commercial standard colour charts are available in which 7 stages of ripening were reproduced and translated to a numerical scale where Stage 1 = green, 2 = light green, 3 = more green than yellow, 4 = more yellow than green, 5 = yellow with extremity green, 6 = yellow, 7 = yellow with black spots (Tapre and Jain., 2012). In banana, post harvest compositional changes following are important since banana is a climacteric fruit. During the ripening process, there are many biochemical changes, including intense increase in ethylene production, respiration, hydrolysis of starch, increase in sugar content, lower pH and reduction of organic acids,

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pigment synthesis, chlorophyll regression and solubilization of pectic compounds (Grierson et al., 1981, Lizada, 1993).
Modified atmosphere packaging (MAP) of fresh banana refers to the technique of sealing actively respiring banana in polymeric film packages to modify the O_2 and CO_2 levels within the package atmosphere. It is often desirable to generate an atmosphere low in O_2 and/or high in CO_2 to influence the metabolism of the product being packaged or the activity of decay-causing organisms to increase storability and/or shelf life (Workneh et al. 2009). In addition to atmosphere modification, MAP vastly improves moisture retention, which can have a greater influence on preserving quality. Further more, packaging isolates the productfrom the external environment and extends the shelf life of the produce (Beaudry, 2000).

Investigations on the use of polypropylene bags for extending the green life of plantain fruits have been carried out (Loa et al., 2017). This study proposes to follow some biochemical parameters of plantain stored with polypropylene packaging.

Material And Methods:

Plant material:
In this study two varieties of plantain such *Corne 1* and *French 2* were used. These plantain varieties harvested at 70th and 75th days after floral apparition were obtained from plantations of Yamoussoukro area (6°49' N and 5°16' O), located in the center of Côte d'Ivoire.

Packages:-
The fruits were packed in polypropylene (PP) bags of thickness 0.235 and 0.303 mm due to 10 kg per bag. The extremity of the bags was firmly closed with a thread.

Storage conditions:-
Ten (10) kg of unpackaged bananas served as a control. The whole of packaged and unpackaged bananas were stored at ambient conditions at 25 °C during 25 days. Every week, a fruit has been removed and subjected to various physicochemical analyzes. The sampling consisted of three batches of plantain.
- Batch 1: control (F70 T, F75 T, C70 T and C75 T)
- Batch 2: fruit packed in PP bags of 0,235 mm thickness (F70 SPI, F75 SPI, C70 SPI and C75 SPI)
- Batch 3: Fruit packed in PP bags of thickness 0.303 mm (F70 SPII, F75 SPII, C70 SPII and C75 SP II).

Biochemical analyzes:-
The hydrogen potential (pH) of the samples was measured with a pH – meter (METROM E 520). Titratable acidity was determined by direct titration of diluted pulp with 0.1 N NaOH as described by Ranganna (1986). Moisture content was determined by desiccation in a drying oven at 105 °C during 24 hours (AOAC, 2005). Reducing sugars were determined according to the method of Bernfeld (1955) using 3.5-dinitro-salicylic acids. The ripening stages were determined by the methods of Lii et *al.* (1982). Proteins contents were measured by Kjeldahl method (AOAC, 2005). Ashes were obtained by calcination in a muffle furnace at 550 °C during 6 hours (AOAC, 2005). Starch content was determined by the formula of Bertrand and Thomas (1910). All determinations were performed in triplicates.

Statistical analysis:
The analysis data were processed using STATISTICA 7.0 software. An analysis of variance (ANOVA) with 3 classification criteria (type of cultivar, degree of maturity and type of packaging) was carried out to evaluate the effect of the type of packaging on the biochemical parameters of the two varieties. The Duncan test at the 5% threshold was used to rank the mean.

Results:

Evolution of pH and titratable acidity during storage at 25 ° C :
Figure 1 and 2 represents respectively pH and titratable acidity of fruit pulp of *French 2* (A) and *Corne 1* (B) varieties harvested at 70th and 75th days, then stored at 25 °C. pH of controls varied significantly from 6.25 to 4.16 and from 6.39 to 4.14 respectively in *French 2* and *Corne 1* varieties harvested at 70th and 75th days. On the other

hand, the pH of both varieties stored with polypropylene bags of thickness 0.235 and 0.303 mm were stable during 16th and 20th days of storage respectively.

The titratable acidity of the control pulps increased significantly ($p < 0.05$) in the two varieties harvested at 70th and 75th days. Figure 2A and 2B showed a stability of titratable acidity during 14 days into fruits packaged in bags of thickness 0.303 mm.

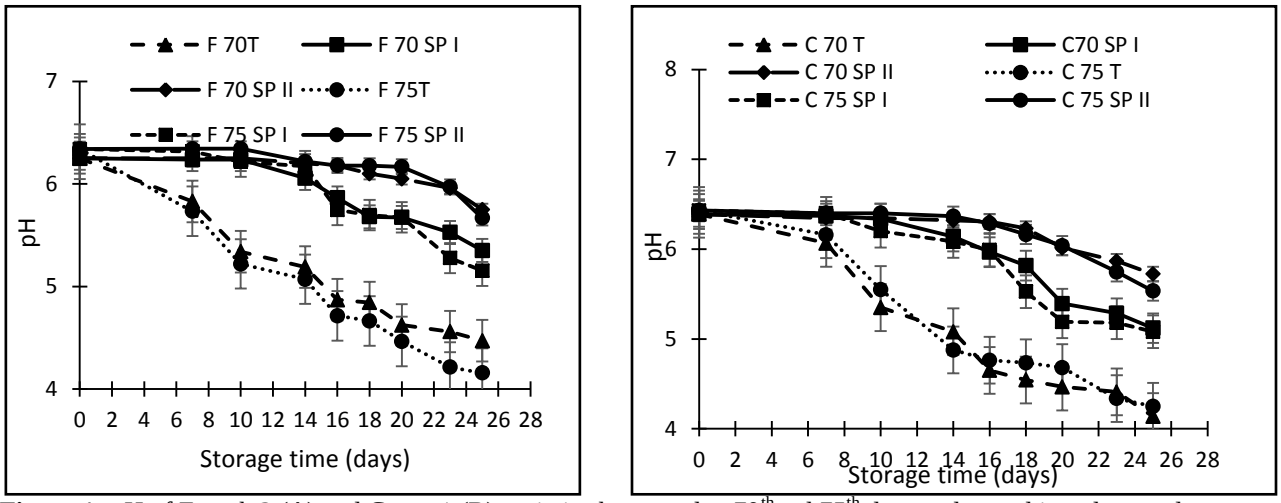
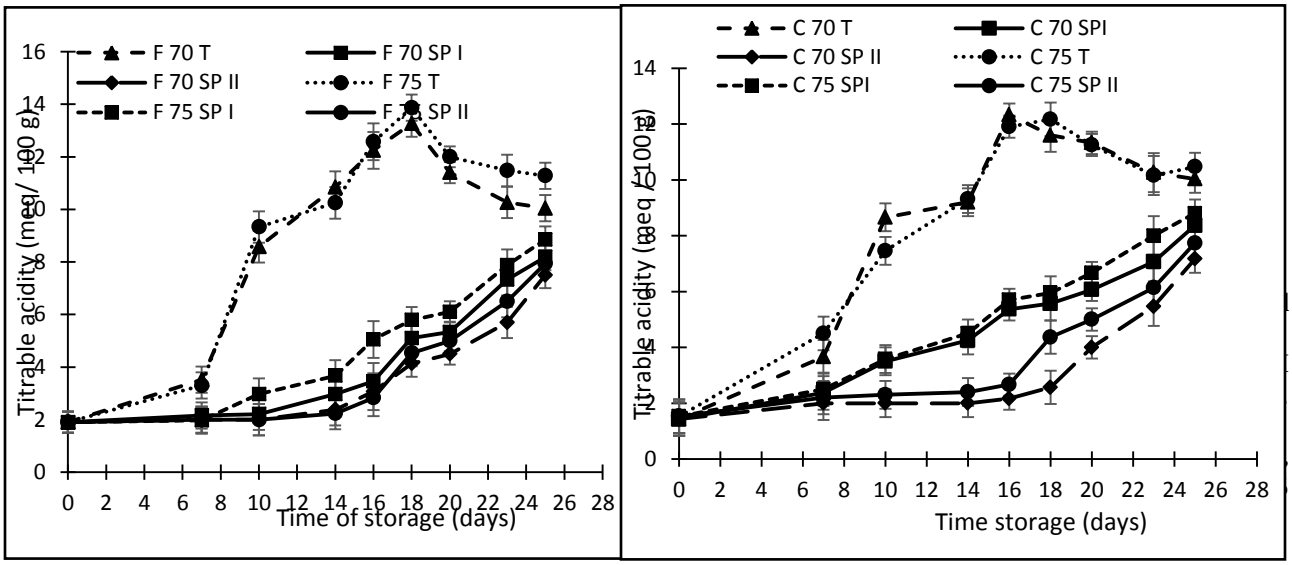


Figure 1: pH of French 2 (A) and Corne 1 (B) varieties harvested at 70th and 75th days and stored in polypropylene packaging at temperature of 25 °C

F70 T : French 2 Control DM 70, F70 SP I : French 2 DM 70, PP packings (0,235 mm), F70 SP II : French 2 DM 70, PP packing(0,303 mm), F75 T : French 2 control DM 75, F75 SP II : French 2 DM 75, PP packing (0,235 mm), F75 SP II : French 2 DM 75, PP packing(0,303 mm). C70 T : Corne 1 control DM 70, C70 SP I : Corne 1 DM 70, PP packing(0,235 mm), C70 SP II : Corne 1 DM 70, PP packing(0,303 mm), C75 T : Corne 1 control DM 75, C75 SP I : Corne 1 DM 75, PP packing(0,235 mm), C75 SP II : Corne 1 DM 75, PP packing (0,303 mm).



Starch and reducing sugars content:-

Figure 3 and 4 shows the evolution of starch and reducing sugars content of pulp of *French 2* and *Corne 1* varieties harvested at 70th and 75th days, then stored at 25 °C.

In control fruits, Starch content varied from 56.41 to 2.31 % and from 59.27 to 2.26 % respectively in fruit pulps of *French 2* and *Corne 1* varieties. This parameter decreased significantly. Paralely, sugar reducing increased significantly during storage into both varieties control. Into Fruits packaged with polypropylene (0.303 mm tickness) the result showed a stability of sarch and reducing sugar during 16 and 18 days of storage into *Corne 1*and *French2* respectively. In the 0.235 mm thick bags, the starch contents of the pulps of both varieties remained stable for 14th days. Regarding reducing sugar, a stability was observed during 12 and 10 days respectively into *French 2* and *Corne 1*.

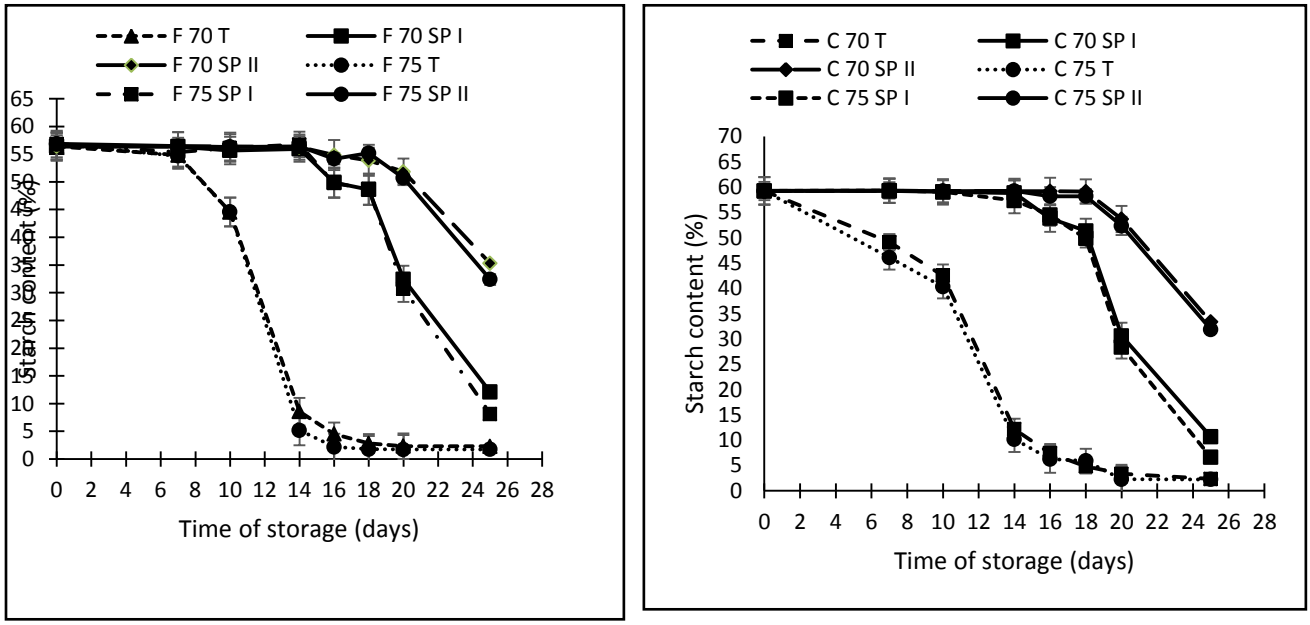


Figure 3:-Evolution of the reducing sugar content of the fruit pulp of the French 2 (A) and Corne 1 (B) varieties harvested at 70th and 75th days and stored in polypropylene packaging at temperature of 25 °C

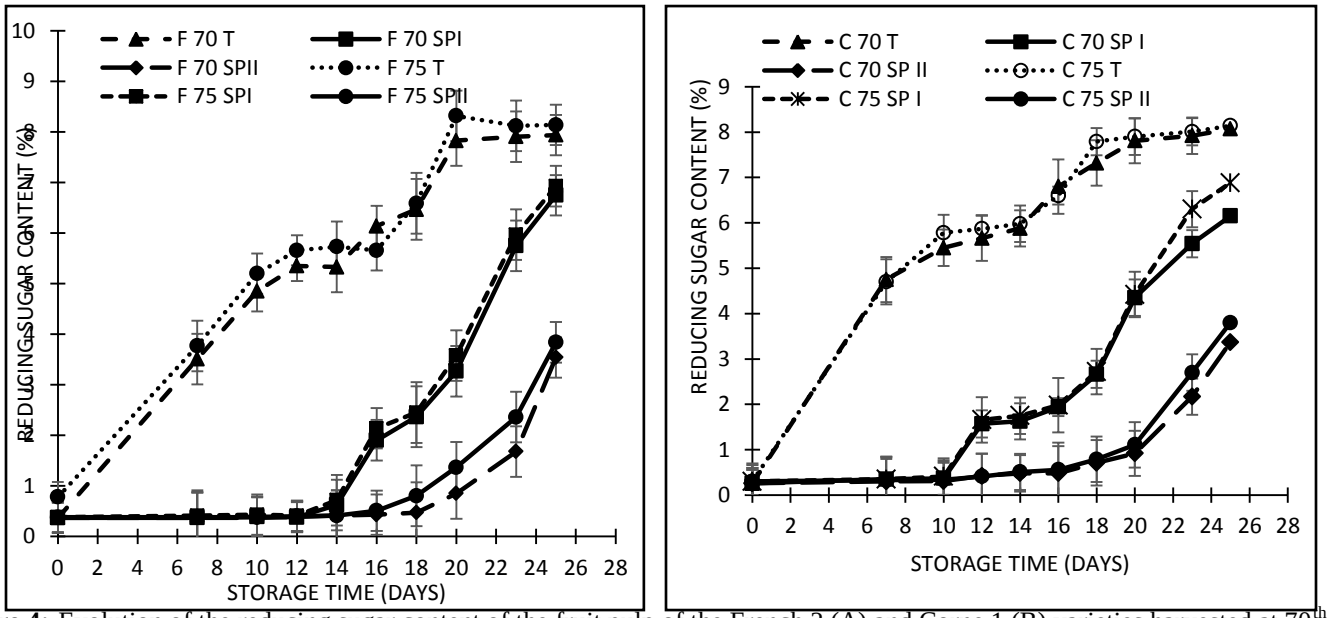


Figure 4:-Evolution of the reducing sugar content of the fruit pulp of the French 2 (A) and Corne 1 (B) varieties harvested at 70th and 75th days and stored in polypropylene packing at temperature of 25 °C

F70 T : *French 2* Control DM 70, F70 SP I : *French 2* DM 70, PP packings (0,235 mm), F70 SP II : *French 2* DM 70, PP packing(0,303 mm), F75 T : *French 2* control DM 75, F75 SP II : *French 2* DM 75, PP packing (0,235 mm), F75 SP II : *French 2* DM 75, PP packing(0,303 mm). C70 T *: Corne 1* control DM 70, C70 SP I : *Corne 1* DM 70, PP packing(0,235 mm), C70 SP II : *Corne 1* DM 70, PP packing(0,303 mm), C75 T : *Corne 1* control DM 75, C75 SP I : *Corne 1* DM 75, PP packing(0,235 mm), C75 SP II : *Corne 1* DM 75, PP packing (0,303 mm).

Ripening stage, moisture, ash and protein content:-

These parameters were showed into table 1 and table 2. The results of ripening stages show that the control spend 7 days to pass from green stage at more yellow than green stage, while the more advanced stage such as the yellow with extremity green is observed after 18 and 20 days of storage respectively in packaging in PP of thickness 0,235 and 0,303 mm.

The moisture content was found increased till last day of storage. They ranged from 60.07 to 70.08 % and from 61.64 to 71.79 % with a significant increase observed from the 7^{th} and 25^{th} day respectively in the control pulps of *French 2* and *Corne 1* varieties. In fruit pulps packed in 0.235 mm thick bags, moisture content was stable until 14^{th} and 16^{th} days respectively in *Corne 1* and *French 2* varieties. On the other hand, in packages of thickness 0.303 mm, this stability was observed in the same varieties until 20^{th} days. Beyond these periods of stability, moisture content increased significantly in fruit pulpe packed.

Proteins contents increased significantly ($p < 0.05$) in the control pulps during storage of *French 2* and *Corne 1* varieties. On the other hand, the proteins contents remained stables for 16^{th} to 18^{th} days and 20^{th} days in the fruits packaged respectively in the bags of thickness 0.235 and 0.303 mm.

For controls, ash content increased of 1^{st} to 25^{th} days from 1.86 to 3.67 % and from 2.27 to 3.72 % respectively in *French 2* and *Corne 1* varieties. These parameters were stable for 14^{th} and 20^{th} days respectively in both varieties stored into the bags of thickness 0.235 and 0.303 mm.

Table 1:-Effect of polypropylene packaging on evolution of ripening stage and biochemical characteristics of French 2 variety harvested at 70^{th} and 75^{th} days and stored of 25 ° C.

Treatments	Storage time (days)	Ripening stage	Moisture (%)	Ash (%)	Proteins (%)
F T 70	1	Green	60,07 ± 0,8 a	0,37 ± 0,05 a	3,38 ± 1,4 a
	7	More yellow than green	62,33 ± 1,3 b	0,38 ± 0,04 a	3,41 ± 0,8 a
	14	Yellow with black spots	66,21 ± 0,9 c	0,7 ± 0,02 b	5,25 ± 0,5 b
	18	All black	66,73 ± 1,4 c	0,73 ± 0,02 b	5,6 ± 0,2 b
	20	All black	67,51 ± 0,8 c	0,71 ± 0,02 b	5,61 ± 0,2 b
	25	All black	68,94 ± 1,3 c	0,76 ± 0,04 b	5,74 ± 0,6 bc
F SPI 70	1	Green	60,07 ± 0,8 a	0,37 ± 0,05 a	3,38 ± 0,8 a
	7	More green than yellow	60,13 ± 0,5 a	0,36 ± 0,01 a	3,38 ± 0,8 a
	14	More green than yellow	60,72 ± 1,2 a	0,37 ± 0,02 a	3,41 ± 0,2 a
	18	Yellow with extremity green	63,31 ± 0,6 b	0,45 ± 0,01 b	4,51 ± 0,2 b
	20	Yellow with black spots	64,66 ± 1,1 b	0,53 ± 0,02 c	4,32 ± 0,2 b
	25	All black	66,55 ± 0,9 c	0,73 ± 0,03 d	5,11 ± 0,6 c
F SPII 70	1	Green	60,07 ± 0,8 a	0,37 ± 0,05 a	3,38 ± 0,8 a
	7	Green	60,15 ± 0,7 a	0,37 ± 0,05 a	3,37 ± 0,8 a
	14	Ligth green	60,73 ± 1,1 a	0,36 ± 0,02 a	3,41 ± 0,2 a
	18	More green than yellow	60,89 ± 1,3 a	0,37 ± 0,02 a	3,39 ± 0,2 a
	20	Yellow with extremity green	61,02 ± 0,6 a	0,38 ± 0,02 a	3,42 ± 0,2 a
	25	yellow	63,41 ± 0,4 b	0,54 ± 0,04 b	4,25 ± 0,6 b
F T 75	1	Green	60,44 ± 1,3 a	0,38 ± 0,01 a	3,38 ± 0,7 a
	7	More green than yellow	62,75 ± 0,6 b	0,37 ± 0,04 a	3,43 ± 0,6 a
	14	Yellow	66,31 ± 1,1 c	0,73 ± 0,02 b	5,33 ± 0,3 b
	18	Yellow with black spots	68,01 ± 0,7 d	0,72 ± 0,02 b	5,53 ± 0,3 b
	20	All black	69,4 ± 0,8 d	0,76 ± 0,04 b	5,73 ± 0,3 c
	25	All black	70,08 ± 1,3 d	0,77 ± 0,01b	5,83 ± 0,3 c
	1	Green	60,44 ± 1,3 a	0,38 ± 0,01 a	3,38 ± 0,7 a

F SPI 75	7	More green than yellow	60,34 ± 0,8 a	0,38 ± 0,01 a	3,39 ± 0,8 a
	14	More green than yellow	60,82 ± 1,1 a	0,37 ± 0,01 a	3,52 ± 0,2 a
	18	Yellow	63,5 ± 0,6 b	0,51 ± 0,01 c	4,36 ± 0,2 b
	20	Yellow with black spots	64,83 ± 0,7 b	0,56 ± 0,02 c	4,74 ± 0,2 b
	25	All black	66,95 ± 1,2 c	0,74 ± 0,03 d	5,16 ± 0,6 c
F SPII 75	1	Green	60,44 ± 1,3 a	0,38 ± 0,01 a	3,38 ± 0,7 a
	7	Green	60,71 ± 0,8 a	0,37 ± 0,01 a	3,37 ± 0,8 a
	14	Ligth green	60,97 ± 0,3 a	0,38 ± 0,01 a	3,38 ± 0,2 a
	18	More green than yellow	61,43 ± 1,1 a	0,37 ± 0,02 a	3,45 ± 0,2 a
	20	More yellow than green	61,32 ± 0,9 a	0,38 ± 0,02 a	3,45 ± 0,2 a
	25	Yellow	64,7 ± 0,6 b	0,55 ± 0,03b	4,48 ± 0,6 b

Data on the same column with different miniscule letters are significantly different ($p \leq 0.05$). FT70 : Var. *French 2* control DM 70, FSPI 70 :Var. French 2DM 70 PP packings (0,235 mm), FSPII 70 Var. French 2 DM 70 PP packings (0,303 mm), FT75 : Var. *French 2* control DM 75, FSPI 75 :Var. French 2DM 75 PP packings (0,235 mm), FSPII 75 : Var. French 2DM 7 PP packings (0,303 mm).

Table 2 : Effect of polypropylene packaging on evolution of ripening stage and biochemical characteristics of *Corne 1* variety harvested at 70^{th} and 75^{th} days and stored of 25 ° C.

Treatments	Storage time (days)	Stage of ripening	Moisture %	Ash %	Proteins %
C T 70	1	Green	61,5 ± 0,5 a	0,4 ± 0,05 a	4,16 ± 0,6 a
	7	More yellow than green	63,56 ± 0,7 b	0,58 ± 0,03 b	4,48 ± 0,4 a
	14	Yellow with black spots	66,33 ± 1,1 c	0,73 ± 0,02 c	5,86 ± 0,6 b
	18	All black	69,33 ± 0,5 d	0,76 ± 0,02 c	5,88 ± 0,6 b
	20	All black	69,98 ± 0,4 d	0,76 ± 0,14 c	5,91 ± 0,3 b
	25	All black	70,15 ± 0,2 d	0,75 ± 0,01 c	5,91 ± 0,7 b
C SPI 70	1	Green	61,5 ± 0,5 a	0,4 ± 0,05 a	4,16 ± 0,6 a
	7	More green than yellow	61,53 ± 0,5 a	0,43 ± 0,02 a	4,18 ± 0,3 a
	14	More green than yellow	61,96 ± 1,1 a	0,55 ± 0,01 b	4,57 ± 0,2 a
	18	Yellow	65,32 ± 0,7 b	0,52 ± 0,01 b	4,53 ± 0,2 a
	20	Yellow with black spots	65,63 ± 0,3 b	0,56 ± 0,42 b	5,29 ± 0,1 b
	25	All black	67,87 ± 1,1 c	0,71 ± 0,03 c	5,73 ± 0,4 d
C SPII 70	1	Green	61,5 ± 0,5 a	0,4 ± 0,05 a	4,16 ± 0,6 a
	7	Green	61,52 ± 0,7 a	0,41 ± 0,05 a	4,17 ± 0,9 a
	14	More green than yellow	61,57 ± 0,3 a	0,43 ± 0,02 a	4,16 ± 0,5 a
	18	More green than yellow	61,75 ± 0,6 a	0,43 ± 0,02 a	4,19 ± 0,5 a
	20	More yellow than green	61,94 ± 0,6 a	0,51 ± 0,22 b	4,48 ± 0,3 a
	25	Yellow	64,59 ± 0,1 b	0,55 ± 0,04 b	5,12 ± 0,7 b
C T 75	1	Green	61,64 ± 0,8 a	0,4 ± 0,05 a	4,15 ± 0,5 a
	7	Yellow	63,69 ± 0,4 b	0,55 ± 0,04 b	4,57 ± 0,1 a
	14	Yellow with black spots	66,56 ± 1,1 c	0,70 ± 0,02 c	5,73 ± 0,8 b
	18	All black	68,86 ± 0,8 d	0,72 ± 0,02 c	5,83 ± 0,8 b
	20	All black	70,53 ± 0,7 e	0,76 ± 0,04 c	5,87 ± 1,1 b
	25	All black	70,79 ± 1,1 e	0,76 ± 0,01 c	5,93 ± 0,9 bc
C SPI 75	1	Green	61,64 ± 0,8 a	0,4 ± 0,05 a	4,5 ± 0,5 a
	7	More green than yellow	61,62 ± 0,7 a	0,4 ± 0,01 a	4,6 ± 0,7 a
	14	More green than yellow	61,74 ± 0,4 a	0,51 ± 0,01 b	4,58 ± 0,2 a
	18	Yellow	65,72 ± 1,3 b	0,53 ± 0,01 b	4,57 ± 0,2 a
	20	Yellow with black spots	67,18 ± 0,6 c	0,57 ± 0,02 b	5,35 ± 0,1 b
	25	All black	67,97 ± 0,6 c	0,71 ± 0,03 c	5,71 ± 0,7 b
C SPII 75	1	Green	61,64 ± 0,8 a	0,4 ± 0,05 a	4,15 ± 0,5 a
	7	Green	61,67 ± 0,5 a	0,41 ± 0,05 a	4,22 ± 0,3 a
	14	More green than yellow	61,9 ± 0,2 a	0,43 ± 0,02 a	4,25 ± 0,6 a
	18	More green than yellow	62,28 ± 0,8 a	0,44 ± 0,02 a	4,25 ± 0,6 a
	20	More green than yellow	62,27 ± 0,4 a	0,52 ± 0,02 b	4,47± 0,5 a
	25	Yellow	64,96 ± 0,5 b	0,55 ± 0,04 b	5,12 ± 0,2 b

Data on the same column with different miniscule letters are significantly different ($p \leq 0.05$). CT70 : Var.Corne 1control DM 70, CSPI 70 :Var. Corne 1DM 70 PP packings (0,235 mm), CSPII 70 Var. Corne 1 DM 70 PP packings (0,303 mm), CT75 : Var.Corne 1control DM 75, CSPI 75 :Var. Corne 1DM 75 PP packings (0,235 mm), CSPII 75 : Var. Corne 1DM 7 PP packings (0,303 mm).

Discussion:-

The study of the evolution of the biochemical characteristics of *French 2* and *Corne 1* varieties showed significant variations between the unpackaged control samples and the fruits packed in the polypropylene bags. In general, there is a significant change in biochemical characteristics in unpackaged fruit from the 7^{th} day of storage.

The pH of fruit decreases significantly during storage. Similar results have been reported by Assemand et al., (2012). The gradual decline in fruit pH during maturation or storage was attributed to an accumulation of acidic organic materials, such as malic acid, which are generally associated with maturation (Wyman and Palmer, 1964).

The increase in pulp moisture content during ripening may be due to carbohydrate breakdown and osmotic transfer from the peel to pulp due to its high sugar concentration (Izonfuoand Omuaru 1998, John and Marchal1995).

During maturation, starch decreased considerably from green to yellow. Simultaneously, the soluble sugar content increased in pulp of plantains. This synchronism can be explained by the degradation of the starch and the formation of free sugars under the action of the enzymes. Thus, during ripening, plantain starch is hydrolysed by enzymes such as α-amylase (Purgatto et al. 2001; Do Nascimento et al., 2006).

Starch degradation was slower into the pulp packaged. The same result was reported by Salunkhe and Kadam (1995). About these authors banana fruits packaged in polyethylene bag were found to have slower enzymatic activity there by the process of starch degradation was slower than open air kept banana fruits.

The appearance of the stages of ripening is longer in the packed fruits (14 to 18 days) that in the control. Similar results were reported by Dongo et al. (2011). Indeed during ripening the loss of the green color of the pericarp of banana is due to the degradation of chlorophyl, which leaves appear the pigments carotenoides (yellow color). This phenomenon would be delayed in the bags in PP because of the low O_2 contents at the interior of pack (Lepengue et al., 2010; Yao et al., 2014).

The results showed an increase of protein and ash contents during storage. With respect to proteins, it has been attributed to possible enzyme conversion and / or protein synthesis during ripening (Tressel et al., 1975). Similarly, the increase of ash content has been reported by several authors (Nimsung et al., 2007, Ayo-Omogie et al., 2010). However, the increase of protein and ash content is faster in control fruits and slow in fruit packed in polypropylene bags. Indeed, the high level of CO_2 in the conservation medium would slow down the decomposition and synthesis phenomena associated with the ripening of plantain.

The use of polypropylene packaging stabilized plantains parameters up to 14^{th} and 20^{th} days. Similar results were obtained by Yao et al., (2014) and Dongo et al., (2011). The small variations in physicochemical characteristics observed in fruit packed in polypropylene bags could be explained by the presence of CO_2 in these bags. This gas is known for its inhibitory action on the enzymes of the respiratory chain, and especially for its opposition to the action of ethylene, phytohormone stimulating fruit ripening. Authors such as Chamara and al. (2000) and Dupin (1992) have shown in their studies that CO_2 would inhibit the activity of enzymes in the starch degradation chain. All these physiological actions lead to a slowing of the metabolism, thus prolonging the shelf life and stabilizing the physico-chemical characteristics of the fruits during storage (Varoquaux et al., 2002). The shelf-life of PP packages with a thickness of 0.303 mm is significantly ($p < 0.05$) longer than in packages with a thickness of 0.235 mm. Similar results were obtained by Yao et al., (2014). According to these authors, the permeability of the sachets is, in general, inversely proportional to their thickness. The amount of CO_2 accumulated will therefore be higher in polypropylene bags of thickness 0.303 mm than those of 0.235 mm.

Conclusion:-

Modified atmosphere created by the polypropylene bags stabilized biochemical lparameters like pH, titratable acidity, starch ans sugar content, ash, moisture and protein content. These parameters were generaly stable until 14th to 18th into *Corne 1* and *French 2* respectively. However, polypropylene bags 0.303 mm thick produced better results than polypropylene bags with 0.235 mm thick. Significant differences were not observed for the same treatment at maturity levels of 70th and 75th days. The stability time of the biochemical characteristics of *French 2* variety was significantly longer.

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