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Research Article

Effects of the Drying Technique Used on the Contents of Total Polyphenols, Flavonoids and Antioxidant Activity of Five Varieties of Mangoes (Mangifera Indica) Dried in Senegal

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Abstract

The Ziguinchor region (Kaguitte village), where the mango samples were collected, is an area that is very affected by post-school losses of seasonal fruit in general. Faced with this problem, the women in the GIE (economic interest group) have been processing mangoes into by-products for several years, particularly drying, which is one of the mwain techniques for preserving agricultural and food products. It is a process that is used in the production of many food products. To carry out this drying, three techniques were used: the one used by the women of the locality (Normal) and two others with osmotic dehydration for two hours and three hours respectively. After peeling, it was found that the improved varieties Knt and Kt had the highest pulp yields (60% of their total mass) and that the Sl variety had the lowest yield. In this work, we followed the variation of polyphenol contents and antioxidant powers according to the technique and the mango variety. For total polyphenols, the Folin-Ciocalteu method was used and antioxidant activity was assessed with 2,2-diphenyl-1-pycrilhydrazyl (DPPH °). The results showed that the antioxidant power, significantly decreases after treatment of the four varieties (example: Knt normal-AAR=0.83%, Treatment-2h-AAR=0.69% and Treatment-3h-AAR=0.59%) with the exception of Dr variety (Normal-AAR=0.68% and Treatment-2h-AAR=0.79% and Treatment-3h-AAR=0.78%). The determination of total polyphenols in these samples showed a much more obvious variation between varieties and less important after the treatment. Thus we have: Knt (Normal-0.07g/100g, treatment-2h-0.03g/100g and treatment-3h-0.19g/100g), Kt (Normal-0.27g/100g, treatment-2h-0.07g/100g and treatment-3h-0.06g/100g) and Sl (Normal-0.11g/100g, treatment-2h-0.07g/100g and treatment-3h-0.21g/100g) Analyses (of Variance and linear models) show that the varieties Knt (treatment-2h-0.0087g/100g and normal-0.0033g/100g), Dr (treatment-2h-0.0023g/100g and normal-0.0019g/100g) and Sl (treatment-2h-0.0023g/100g and normal-0.0017g/100g), respectively, have quite high flavonoid contents. These experimental results show that the technique used (Normal) by the local units preserves the antioxidant compounds well and in some cases it is necessary to treat the different varieties before drying them.

Keywords

Mangifera Indica, Drying, Processing, Polyphenol Content, Antioxidant Capacity

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1. Introduction

The mango (Mangifera indica), a tropical fruit that is well known throughout the world, is produced in large quantities in Senegal, giving it a prominent place in West Africa. Mango production in Senegal is concentrated in Casamance (57%), particularly in the Ziguinchor region. However, in this area there are large losses of mangoes through rotting due to difficult access to production sites and the instability of the region. In addition, concomitant production means that large quantities of mangoes are available on the market and consequently there is a lack of sales. In southern countries, a significant proportion of fruit and vegetables is currently lost after harvesting due to the lack of conservation and processing technologies adapted to local contexts [19]. Post-harvest losses are estimated at around 80% worldwide for mango [11]. [23] estimates these losses at around 60% for Cameroonian mangoes, a rate relatively comparable to post-harvest losses of mangoes in Senegal [12]. To cope with this situation, technologies for processing pulp into juice and nectar, as well as those for making jellies and jams have been experimented with [9, 7]. Processing should become a key stage in the valorisation of mango in ECOWAS countries, where crop losses regularly exceed one third of production and the subsequent loss of earnings is significant. However, the storage of juices in rural areas comes up against conservation problems. In such conditions, work [25, 21] has shown that mango drying is an interesting alternative. Processing takes place in artisanal (women's groups), semi-industrial, and very few industrial units. The finished products from mango processing face a quality problem because some units do not master or do not process according to quality standards. This negatively impacts the nutritional value of mango and derived products, and consequently competitiveness [16]. Chemical changes are observed during drying and can strongly impact the nutritional quality of the processed product. Very few studies on nutritional quality have been conducted so far. The colour thus becomes the main attractive factor and the major attribute of its marketability according to consumers [3]. And even if colour is appreciated by consumers, it is important to know the nature of the active molecules and their behaviour according to the drying technique and the variety processed. Thus, the general objective of this work is to study the variation in total polyphenols, flavonoids and antioxidant activity of five mango varieties after different drying techniques and according to the mango variety used. To carry out this work, we used three drying techniques: the technique without pre-treatment (without osmotic dehydration) most often used by women in Casamance, a technique with pre-treatment (osmotic dehydration) by soaking the mango slices in a sugar solution then heated and cooled for two hours and for three hours following the method of [10]. This study can help to understand the variation of these antioxidant contents according to the dried varieties and the drying technique used. This study was carried out on five varieties of mangoes grown in southern Senegal (in the village of Kaguitt), two of which are intended for export and the three for local consumption on the one hand and national marketing on the other. The drying was carried out in Kandialan Diola (in the commune of Ziguichor), the region where this activity is most common.

2. Materials and Methods

2.1. Materials

2.1.1. Samples

The mango samples were collected from an orchard in the village of Kaguitte in the Ziguinchor region, Oussouye department, a locality that has been badly affected by post-school losses. To do this, we took 15 kg of commercially ripe and unwounded mangoes of each variety. The mangoes were kept at the drying centre until they reached the desired level of maturity.

Figure 1. *Mango rot in Casamance [24].*

2.1.2. Drying Equipment

The technology used is a natural convection gas dryer with 42 racks. The dimensions are Length (outside): 6.96 m; width (outside): 2.438 m; height (outside): 2.591 m. There are also materials that accompany the dryer such as: scales, plastic basins, peeling knives, gloves, nose covers, gowns etc. The drying time is twelve hours.

Figure 2. *Dryer at Kandialan Diola (in the commune of Ziguinchor).*

2.2. Method

2.2.1. Drying Stages

The mangoes are sorted, washed with drinking water, drained and weighed. After peeling and pitting, the mangoes are sliced. The skins, pits and pulp are weighed. For drying without pre-treatment, the slices are placed directly on the racks. With pre-treatment, the slices are placed in a sugar solution with a concentration of 350g/L and the whole is heated for two hours or for three hours. The slices are then placed on the racks, leaving space between them for drying. The slices are packed in bags using an air aspirator.

Figure 3. *Mango slice being processed, mango slices on the rack and mango bags dried.*

2.2.2. Determination of Total Polyphenols, Flavonoids and Antioxidant Activity

Determination of total polyphenols:

For polyphenols, the Folin-Ciocalteu method is used, which consists of oxidising the oxidisable groups of phenols in a basic medium. The blue coloured reduction products have an absorption intensity proportional to the quantity of polyphenols present. The absorbances are read at 760 nm.

In reality, this is a calibration method using a gallic acid solution as a reference polyphenol. From this standard solution, daughter solutions with concentrations varying from 0.01 to 0.1g/L are prepared. The OD = f (C) curve, i.e. the linear (affine) response calibration curve, can thus be drawn. Thus, the results calculated from the average of three tests are expressed in g of gallic acid equivalents per 100 g of extract.

For this purpose, 50 µl of extract were determined using the Folin-Ciocalteu reagent according to the method developed by [8].

The concentration of total polyphenols is given by the relation:

$$C_P = \frac{(A-b)}{a} * Fd * \frac{v}{1000} * \frac{100}{m}$$

CP: Total polyphenol content expressed in g gallic acid equivalent/100 g;

A: Real absorbance of the sample;

a: Directing coefficient of the calibration line = 3.12;

b: Intercept of the calibration line = 0.0696;

Fd: Dilution factor;

v: Volume of extraction (mL);

m: Test sample (g).

Determination of flavonoids:

The flavonoid content of the extracts is determined using the colorimetric method described by [8]. The results are expressed in g catechin equivalent per 100 g of product.

$$C = \frac{A*Pm}{\varepsilon} * fd * \frac{v}{1000} * \frac{100}{m}$$

C_: Total flavonoid content expressed in g catechin equivalent/100 g;

A: Absorbance of the sample;

Pm: Molar mass of catechin = 290.26 g/mol;

ε: Molar extinction coefficient = 10 332 L/mol;

Fd: Dilution factor;

v: Volume of extraction (mL);

m: Test sample (g).

Antioxidant activity:

It was evaluated with 2,2-diphenyl-1-pycrilhydrazyl (DPPH°) following the method of [1]. In addition, some adjustments were made to this protocol. The method is based on the ability of an extract to donate a singlet electron to the dark purple coloured DPPH free radical to stabilise it at DPPH with a yellow-green colouration. This activity is compared to that of a control antioxidant (quercetin). Thus, 2 mL of DPPH (0.1 mM in alcohol) was introduced into a test tube containing 0.5 mL of sample. The mixture was shaken for five (5) minutes and then incubated in the dark at room temperature for 30 minutes. After this incubation period, the absorbance was read at 517 nm against a blank (0.5 mL sample and 2 mL methanol) using a UV spectrophotometer

(Specord 200 Plus). The free radical scavenging activity is expressed as a percentage of DPPH° reduced according to the equation...

$$AAR\ (\%) = \frac{Absorbance_{control} - Absorbance_{sample}}{Absorbance_{control}}$$

Also, the 50% reducing concentration of DPPH° (IC50) is determined graphically on the free radical scavenging activity (FSA) versus pulp concentration curve.

3. Results and Discussion

3.1. Evaluation of the Masses of Dried Varieties

The mango consists mainly of three parts: the exocarp, the mesocarp and the core. More or less flattened laterally, the mango has a variable weight (100 to 1200g) depending on the variety [22]. In this table, we have represented the masses of skin, stones and kernel for five kilograms of each variety.

Table 1. *The different masses.*

Varieties	Gross mass (kg)	Skin mass (kg)	Core mass (kg)	Slice mass (kg)
Bk	5	0,9 ±0,50	1,5 ±0,80	2,6 ±0,55
SL	5	0,89 ±0,40	1,9 ±0,50	2,2 ±0,32
Knt	5	1 ±0,45	1 ±0,67	3 ±0,50
Kt	5	1,2 ±0,72	1,3 ±0,80	3 ±0,57
Dr	5	0,9 ±0,65	1,4 ±0,75	2,7 ±0,67

The results shown in Table 1 show that the variety kt (keitt) has the highest skin mass, i.e. 24% of its total mass, followed by the variety knt (kent) 20% of its total mass. The three local varieties have the lowest epidermal mass, i.e. 18% of their total mass. These local varieties have respectively the highest core masses: Sl (Sierre-léon) 38% of its mass, Bk (Boukodiékhal) 30% and Dr (Diourrou) 28% and the improved varieties have the lowest core masses (knt 20% and kt 26%). Instead of being thrown away, these parts could be used in the food industry. Indeed, the mango peel is known to be a source of high quality pectin. The highest pulp yields are found in the knt and kt varieties (60% of their total mass). The local variety Sl has the lowest pulp yield. Compared to the varieties studied by [18], the kt, knt and Dr varieties show more interesting pulp yields.

3.2. Study Variables

Contents:

1. Polyphenols (g/100g)
2. Flavonoids (g/100g)
3. Antioxidant power (%)

Varieties studied: Kent (Knt), Diourrou (Dr), Keitt (Kt) Boukodiékhal (BK) and Sierra-léon (SL).

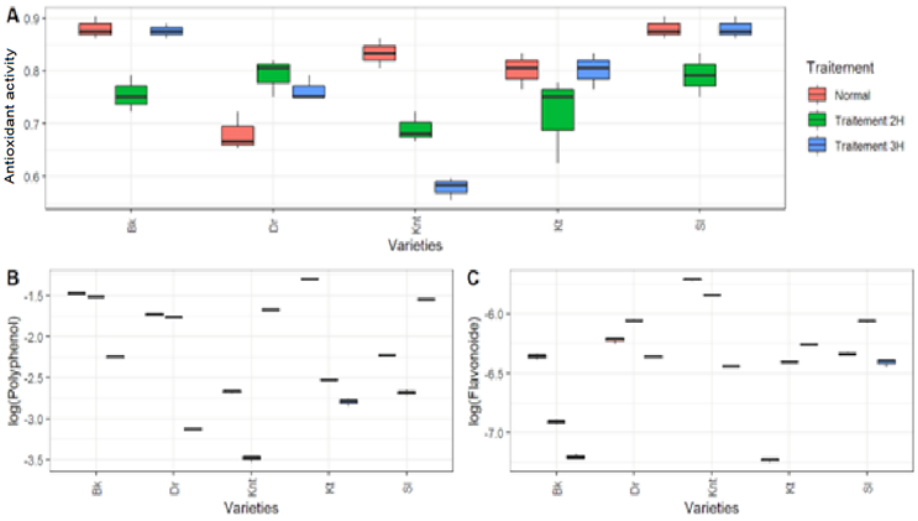

Figure 4. *Description of the variation in antioxidant levels according to treatment and variety.*

3.2.1. Descriptive Analyses

To understand the variation in antioxidant activity, total polyphenol and flavonoid content according to the drying technique used or the variety dried, descriptive analyses were first carried out. The results of these analyses are shown in Figure 4.

These results show a variation in antioxidant content depending on the treatment technique used and the variation. To confirm these results, the Kruskal Wallis test was performed in the table below.

Table 2. *Kruskal Wallis test.*

statistic	p.value	parameter	method	Test
17.55215140773	0.001509257165766	1	Kruskal-Wallis rank sum test	Antioxydant_activity-Varieties
6.53673717481156	0.0380684818436683	2	Kruskal-Wallis rank sum test	Antioxydant_activity-Traitement
8.59155775215081	0.0721600427121285	3	Kruskal-Wallis rank sum test	Polyphenol-Varieties
6.31009774848986	0.0426363171239236	4	Kruskal-Wallis rank sum test	Polyphenol-Traitement
17.1760107165602	0.00178650785641088	5	Kruskal-Wallis rank sum test	Flavonoide-Varieties
5.59341195072138	0.0610107027451508	6	Kruskal-Wallis rank sum test	Flavonoide-Traitement

According to the results of this test, the antioxidant activity varies significantly depending on the variety and the treatment considered. It is therefore a function of variety and treatment. The treatment of the samples significantly affects their polyphenol content independently of the variation of the treated variety (p = 0.072). If we consider the flavonoid contents, the treatment of the samples does not vary their contents, whereas samples from different varieties have significantly different flavonoid contents.

In order to understand these observations, we will carry out analyses for each content according to treatment and variety.

3.2.2. Variation in Antioxidant Capacity

Antioxidant capacity can also be assessed as the potential to scavenge free radicals, by directly measuring radical inhibition upon addition of the antioxidant compound [13]. Antioxidant capacity is the primary physiological role attributed to polyphenols defining an antioxidant as "a substance that, when present at low concentrations relative to that of an oxidizable substrate, significantly retards or inhibits its oxidation" [10].

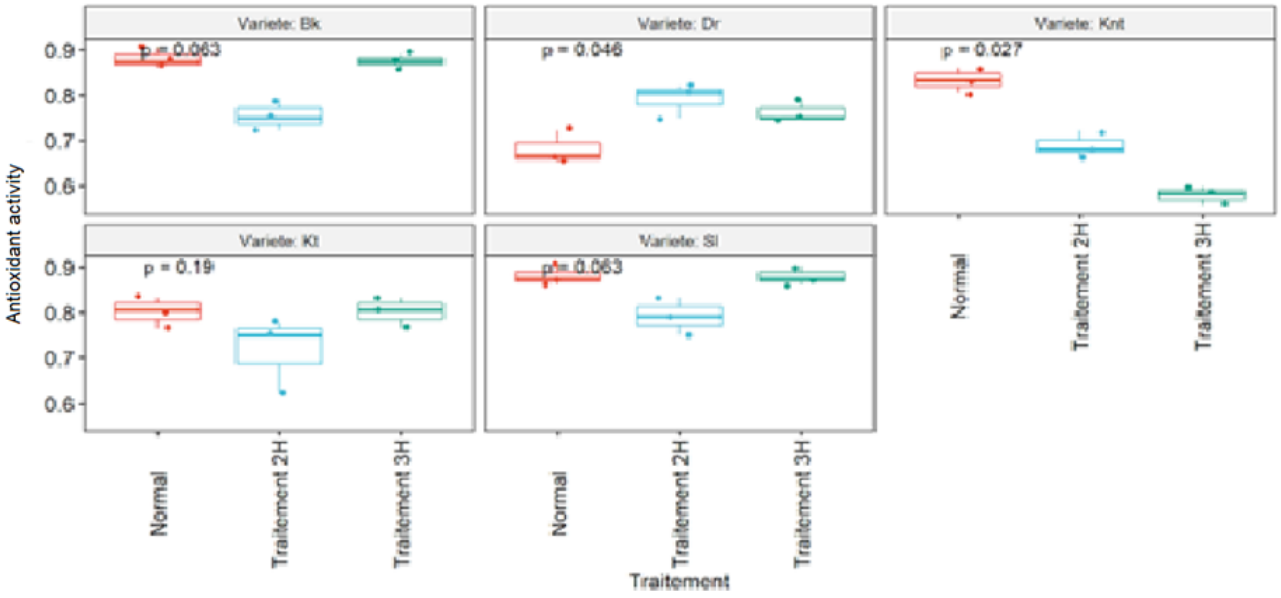

Figure 5. *Average variation in antioxidant activity by treatment by variety.*

In Figure 5, we show the results of the average variation in antioxidant activity according to the drying technique used and the variety dried.

The analysis of this graph reveals that for the varieties Bk, Knt, Kt and Sl, the treatment undergone by the samples considerably decreases (in places significantly ex Knt) their antioxidant activity.

It is only for the variety Dr that the treatments significantly increase the antioxidant activity of the samples. It appears that antioxidant activity varies with treatment and dried variety. An analysis of variance in Figure 6 will support these results.

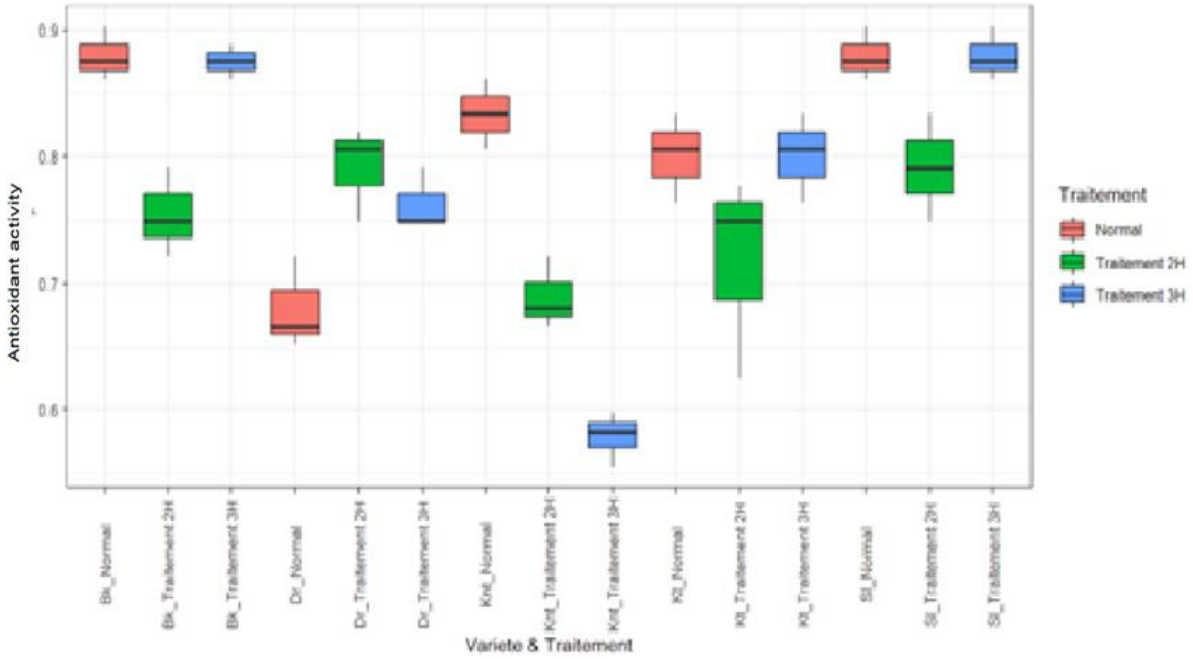

Figure 6. *Analyses of variance of antioxidant capacity.*

The results of this analysis of variance show that the antioxidant activity varies according to the dried variety and the treatment used. The variation of this activity according to the treatment is clearly visible by taking as an example the variety Knt where for the normal treatment (AAR=0.83%), the treatment-2h (AAR=0.69%) and treatment-3h (AAR=0.59%). It should also be noted that only in the Dr variety does the 2h treatment increase antioxidant activity. For the other four varieties, the opposite is noted, while for a 3h treatment, values comparable to the normal treatment are noted. According to the varieties, we observe that Bk and Sl present the best antioxidant activities (AAR=0.88%).

3.2.3. Variation of Total Polyphenol Content

Polyphenols are compounds with a high health potential in humans, especially due to their antioxidant capacity. Mango, as well as guava and lychee, stand out from other tropical fruits because of their high content of polyphenols (or phenolic compounds) [5]. Phenolic compounds all contain a benzene ring substituted by hydroxyl group(s) [4]. The resulting 'radical' phenolic compound is stabilised by the delocalisation of electrons on the benzene ring. This reaction therefore leads to the conversion of a highly reactive peroxyl radical into a less reactive phenoxyl radical. This antioxidant capacity (capture of reactive oxygen species) is even greater for phenolic compounds with two hydroxyl groups in ortho. These are therefore also more sensitive to oxidation [6].

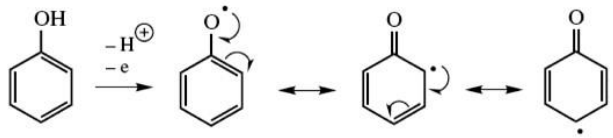

Figure 7. *Single-electron oxidation of a phenol.*

In this figure 8, the results of the average variation of total polyphenol contents according to the variety and the treatment used are shown.

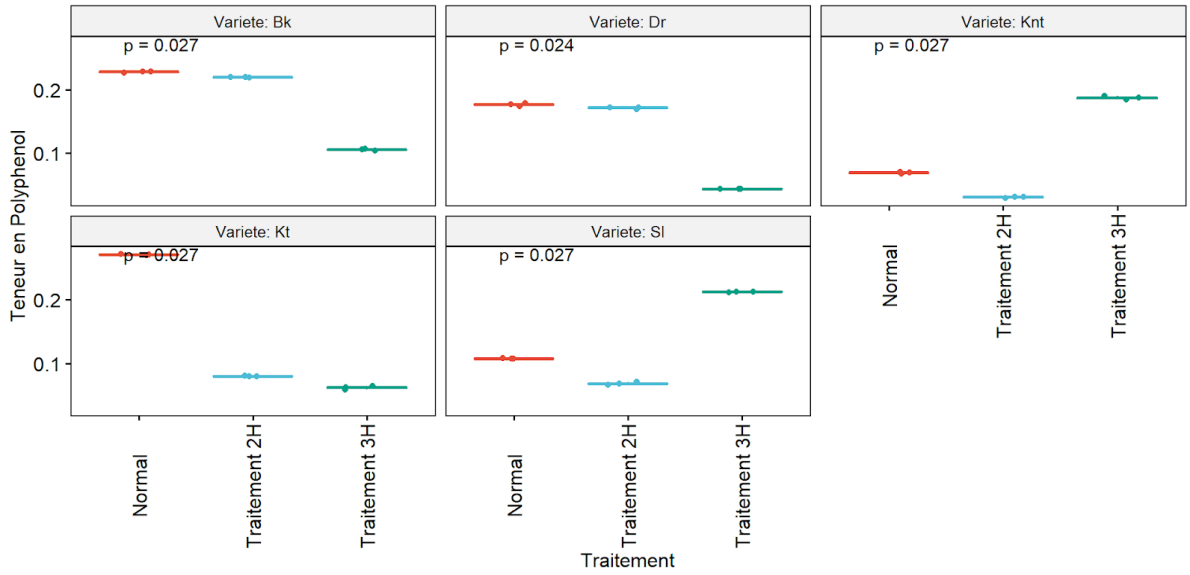

Figure 8. *Average variation in total polyphenol content according to treatment by variety.*

For the varieties Bk, Dr and Kt, the treatment undergone by the samples significantly decreases their Polyphenol contents. In contrast to Knt and Sl varieties where the 3H treatments significantly increase the polyphenol contents of the samples. According to these results, a variation in polyphenol content can be observed depending on the technique used. It appears from this that the polyphenol content varies according to the dried varieties. In order to support this thesis, we have carried out analyses of variance in Figure 9.

Since the analysis in figure 8 allowed us to observe the variation in polyphenol content according to the treatment, the analysis of variance allows us to observe this variation according to the variety and the treatment used.

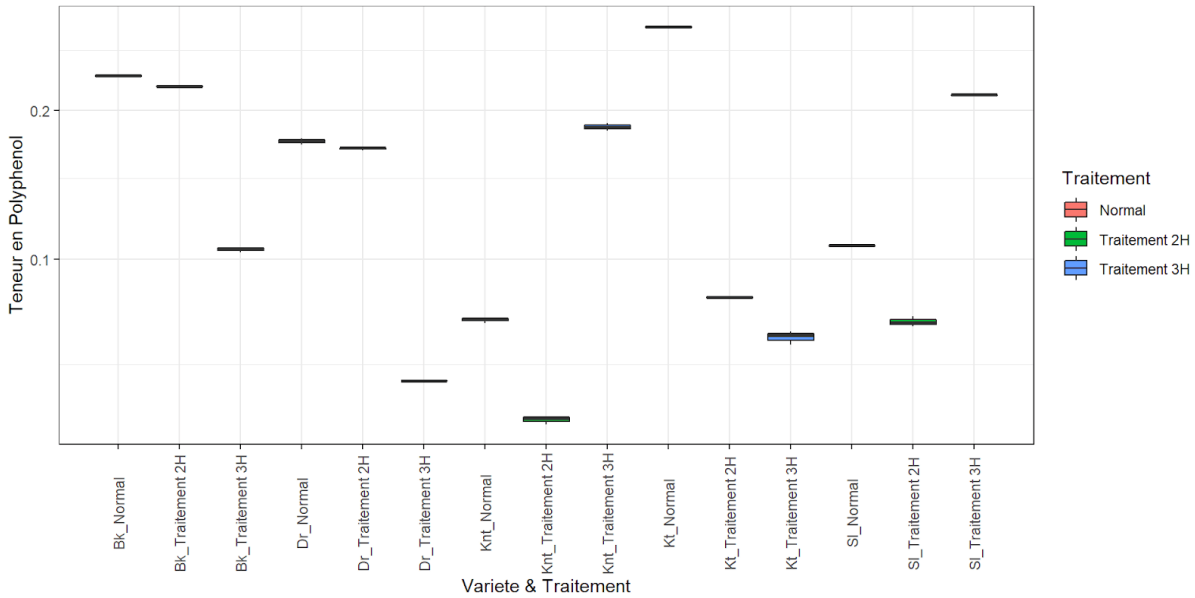

Figure 9. *Analysis of variance of total polyphenol content.*

The results of this analysis of variance confirm the variation in polyphenol content according to the treatment used. This variation according to the treatment used is much more evident with the varieties: Knt (Normal-0.07g/100g, treatment-2H-0.03g/100g and treatment-3H-0.19g/100g) Kt (Normal-0.27g/100g, treatment-2H-0.07g/100g and treatment-3H-0.06g/100g) and Sl (Normal-0.11g/100g, treatment-2H-0.07g/100g and treatment-3H-0.21g/100g) These results are in agreement with those of the Kruskal Wallis Test in Table 1. However, to obtain high polyphenol contents, it is

necessary to treat some varieties and not others. The highest contents are observed respectively in the varieties: Kt (Normal-0.27g/100g), Sl (treatment-3H-0.21g/100g) and Knt (treatment-3H-0.19g/100g). These three varieties have higher polyphenol contents than those studied by [14] (concentration 5, 72%). Comparing the polyphenol contents between these varieties, it seems that there are no significant variations. To find out if there are significant variations in polyphenol content between dried varieties, we ran a linear model. This model consists in setting the Normal Status of the variety Kt and then comparing it with all other statuses. To do this we set the Normal Status of the variety Kt as a reference in order to model this hypothesis using a GLM (Generalized Linear Model) with a Negative Binomial distribution which is generally the best adapted for decimal data. Thus, the results of this model are reported in the table below.

Table 3. *General linear model.*

	Estimate	Std.Error	T value	Pr(>| t |)
(Intercept)	0.271163929722434	0.000916883132164157	295.7453751617	1.53772090768122e-53
Var_TraitBk_Normal	-0.0432880655047124	0.00129666856061767	-33.3840634526467	2.77185583153845e-25
Var_TraitBk_Traitement 2H	-0.0515947583547162	0.00129666856061767	-39.7902439541982	1.60257873049283e-27
Var_TraitBk_Traitement 3H	-0.165650314814456	0.00129666856061767	6127.750698864441	1.30044279694663e-42
Var_TraitDr_Normal	-0.0947585419045677	0.00129666856061767	-73.0784602808824	2.33102035308028e-35
Var_TraitDr_Traitement 2H	-0.1001554919440834	0.00129666856061767	-77.2406264659677	4.46223176923494e-36
Var_TraitDr_Traitement 3H	-0.227522689469192	0.00129666856061767	-175.467113477951	9.65076321928891e-47
Var_TraitKnt_Normal	-0.202109703578171	0.00129666856061767	-155.86843833238	3.35773410090152e-45
Var_TraitKnt_Traitement 2H	-0.240564571238518	0.00129666856061767	-185.525105292847	1.81552017768511e-47
Var_TraitKnt_Traitement 3H	-0.0841574641771561	0.00129666856061767	-64.9028338722637	8.0146400036333e-34
Var_TraitKt_Traitement 2H	-0.191264969204063	0.00129666856061767	-147.504902187922	1.75263160074666e-44
Var_TraitKt_Traitement 3H	-0.209975273265338	0.00129666856061767	-161.934421518877	1.06951976234962e-45
Var_TraitSl_Normal	-0.163535249950469	0.00129666856061767	-126.119545824854	1.91080512577693e-42
Var_TraitSl_Traitement 2H	-0.202930829983875	0.00129666856061767	-126.119545824854	1.91080512577693e-42
Var_TraitSl_Traitement 3H	-0.0589477158491039	0.00129666856061767	-45.4608969781946	3.13681773882054e-29

According to the results of this model, it can be observed that all the values are negative, so the total polyphenol content varies according to the treatment used and the variety.

However, these variations in polyphenol contents are more marked in relation to the treatments than to the varieties.

3.2.4. Variation in Flavonoid Content

Flavonoids are low molecular weight phenolic compounds with a C6-C3-C6 carbon skeleton (flavan ring). The two aromatic rings define the A and B rings and the central heterocycle (pyran) is named C (Figure 9) [20]. There are different subclasses of flavonoids depending on the degree of oxidation of this heterocycle. Several studies have shown the role of flavonoids in deactivating free radicals [6].

Flavonoids act mainly as primary antioxidants, stabilising peroxide radicals, but they can also deactivate reactive oxygen species (superoxide ion, OH- radical, singlet oxygen), inhibit lipoxygenase or chelate metals [17]. In the figure below, we have the results of the analysis of the variation of flavonoid contents.

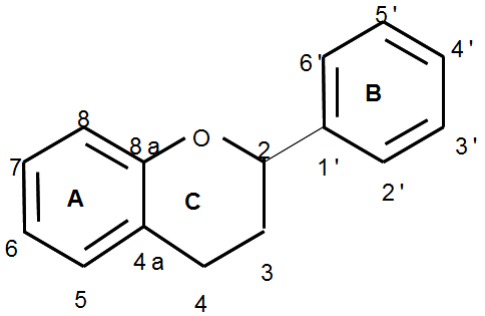

Figure 10. *Generic structure of flavonoids.*

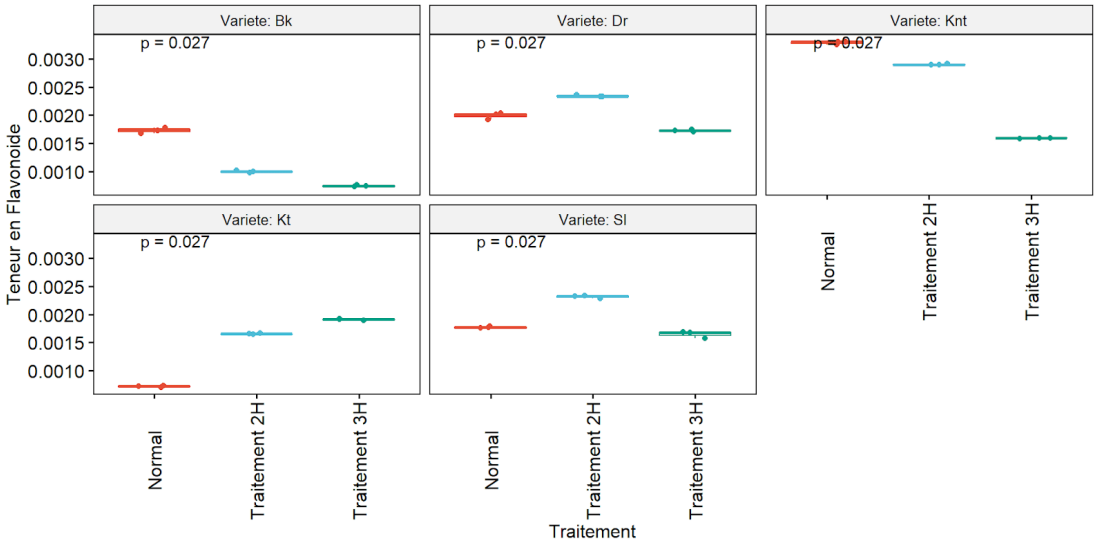

Figure 11. *Variation in flavonoid content according to treatment by variety.*

For the varieties Bk and Knt the treatment of the samples significantly decreases their Flavonoid content. In contrast to the varieties Dr, Kt and Sl where the 2h and/or 3h treatments would significantly increase the flavonoid contents of the samples. From these results, a variation in flavonoid content is observed. It also seems that this variation is a function of the dried variety.

To confirm or refute this hypothesis, we performed an analysis of variance of the flavonoid contents and the results are reported in the table below.

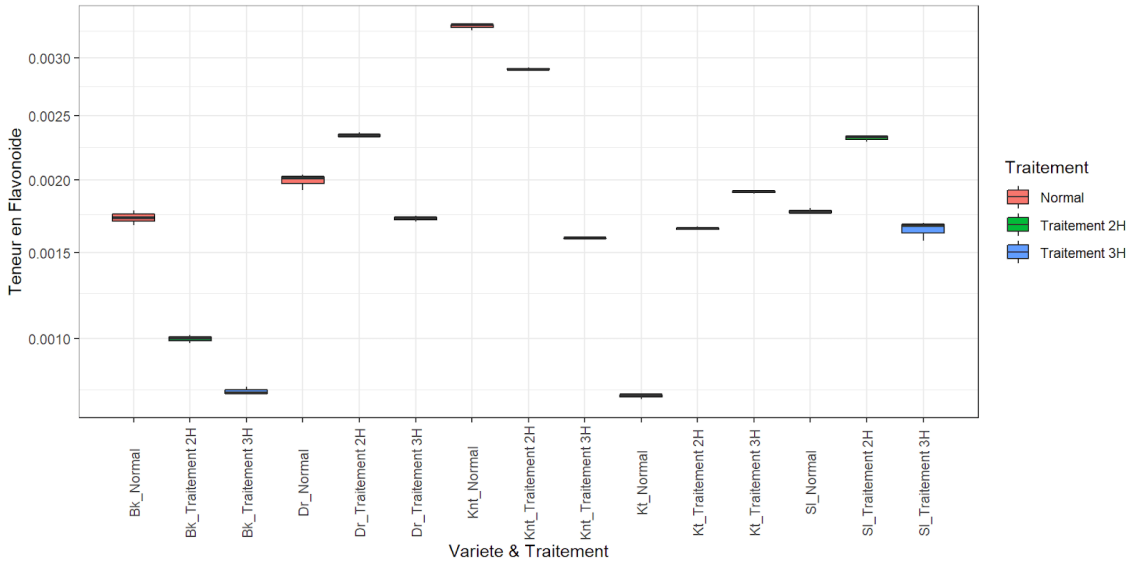

Figure 12. *Analysis of variance of flavonoid content.*

According to the results of this analysis, there is a very significant variation in flavonoid content depending on the technique used. If we take as an example the varieties: knt (normal-0.0033g/100g and treatment-3h-0.0016g/100g), Bk (normal-0.0017g/100g and treatment-3h-0.0005g/100g). This analysis of variance confirms that the flavonoid content depends on the treatment used. Looking at the graph, it seems that there is a variation in flavonoid content depending on the variety dried. To address this hypothesis, we performed a generalized linear model.

In this generalized linear model, we set Knt-Normal as the reference. The results of this model are reported in the table below.

Table 4. *Generalized linear model.*

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.0032929160	1.790605e-05	183.89961	2.363522e-47
Var TraitBk_Normal	-0.0015627064	2.532298e-05	-61.71100	3.599008e-33
Var TraitBk_Traitement 2H	-0.0022941328	2.532298e-05	-90.59489	3.805771e-38
Var TraitDr_Normal	-0.0013003009	2.532298e-05	-51.34865	8.497852e-31
Var TraitDr_Traitement 2H	-0.0009479371	2.532298e-05	-37.43387	9.659508e-27
Var TraitDr_Traitement 3H	-0.0015671041	2.532298e-05	-61.88466	3.310134e-33
Var TraitKnt_Traitement 2H	-0.0003870155	2.532298e-05	-15.28317	1.065414e-15
Var TraitKnt_Traitement 3H	-0.0016999157	2.532298e-05	-67.12936	2.933120e-34
Var TraitKt_Normal	-0.0025704302	2.532298e-05	-101.50583	1.269119e-39
Var TraitKt_Traitement 2H	-0.0016353630	2.532298e-05	-64.58019	9.297515e-34
Var TraitKt_Traitement 3H	-0.0013795406	2.532298e-05	-54.47781	1.467295e-31
VarTraitSl_Normal	-0.0015186885	2.532298e-05	-59.97274	8.424495e-33
Var TraitSl_Traitement 2H	-0.0009722935	2.532298e-05	-38.39569	4.581076e-27
Var TraitSl_Traitement 3H	-0.0016430183	2.532298e-05	-64.88250	8.089825e-34

The results of this model show that all the values are negative, thus confirming that there is a variation in flavonoid content depending on the treatment and the dried variety. The analyses (Variance and linear model) show that the varieties Knt (Traiment-2h-0.0087g/100g and Traiment-normal-0.0033g/100g), Dr (Traiment-2h-0.0023g/100g and Traiment-normal-0.0019g/100g) and Sl (Traiment-2h-0.0023g/100g and Traiment-normal-0.0017g/100g), respectively, have significant flavonoid contents. The two-hour treatment of these three varieties significantly increases the flavonoid content. The flavonoid content of Knt is higher than Tommy Atkins, Kent, Keitt and Haden (31.2 +/- 7.8 mg GAE / 100 g) [15] while the contents of Dr and Sl are in this range. Variation in flavonoid levels is greater between varieties. These variations in antioxidant levels are observed on the same varieties in the fresh state [2].

4. Conclusion

Many studies have shown the importance of consuming antioxidant-rich foods for human health. However, antioxidant levels can vary depending on many factors. In our previous studies, we noted a variation in antioxidant levels among the five varieties studied, but the same pattern was observed during drying. In this study, depending on the drying technique used, a significant variation in antioxidant content was observed. For some varieties, osmotic dehydration can contribute to an increase or decrease in antioxidant levels during drying. For example, the untreated drying technique (without osmotic dehydration) used by women in Casamance retains antioxidant compounds well and is easier to practice. The local varieties Dr, Sl and Bk, which are little used in drying, have interesting antioxidant contents and could therefore be counted in the processing; moreover, they are the most affected by rotting. The knt variety, which is highly prized by processors, shows significant levels compared to dried varieties. It is therefore important to understand how certain phenolic compounds decrease in one variety and increase in another, knowing that the same drying technique is used? It is also a necessity to use these drying products for certain applications such as clinical treatments.

Abbreviations

Knt	Kent
Dr	Diourrou
Kt	Keitt
BK	Boukodi ékhal
SL	Sierra-l éon

Conflicts of Interest

The authors declare no conflicts of interest.

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