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RESEARCH ARTICLE

Roasting effect on anti-nutritional factors of the *Moringa oleifera* leaves

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Abstract

The *Moringa oleifera* leaves are a preferred feedstock for animal feed, but also for human consumption. They contain anti-nutritional factors that inhibit the bioavailability of its nutrients. Among traditional treatments applied to food, roasting is as easily applicable treatment, which may reduce the anti-nutritional factor and make bioavailable the nutrients. However, these effects on the products depend of the temperature and the treatment duration. Acentered composite experimental design on two factors (temperature: 50-100 ° C, Time: 20-120 min) was use in this work to study the effect of the two parameters on the anti-nutritional factors on the *Moringa oleifera* leaves. The results show that the time and roasting temperature have a negative influence on the water content, oxalate, phytate and total phenols. With a water content between 6.43 and 14.3%, the contents in phytate, oxalate and phenol of the roasting *Moringa oleifera* leaves were respectively ranging from 0.15 to 1.87%, 0.54 to 2.4% and from 1.21 to 3.21%. The lower contents oxalate (1.2 ≤ g/100g DM) were obtained for roasting time greater than 100 minutes at temperatures higher than 90°C and lower than 60°C. In the same way, the lowest contents of phytate (< 0.3g/100g) are obtained for samples roasted during at least 40 minutes at temperatures between 70 and 80°C. Finally roasting *Moringa oleifera* leaves in excess of 65 ° C for at least 90 minutes gives lower levels of phenols (<1.5% gallic acid).
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Introduction:-

In Africa, the traditional vegetables are species of great diversity and multipurpose. They currently occupy a significant place in the human consumption, contribute to the improvement of the nutritional and medicinal needs and are increasingly known for their importance in the food safety of people in Africa rural and urban zones (Madi et *al*., 2012). The traditional vegetables are food with high nutritional value, which fight against malnutrition and the deficiencies in micro-nutriments. *Moringa oleifera* are one of the traditional vegetables most consumed and most known all over the world. In Benin, the request for fresh or dry leaves for the culinary uses quickly grows as information on the nutritional virtues is known country (Silva, 2010).

Many scientific studies showed that the *Moringa oleifera* leaves are actually nutritive sources and can be used as a food additive for multiple ends (Moyo et *al.,* 2011). They are rich in vitamins, certain minerals and are an excellent source of plant protein. They contain a significant quantity of amino acids and essential fatty acids (Broin et *al.*, 2002). However the vegetables leaves of *Moringa oleifera* contain also anti-nutritional factors (phytates, saponins etc…) which inhibit the bioavailability of the nutriments (Foidl et *al.,* 2001; Tchiégang and Aissatou, 2004). Biling, drying, and vapor cooking are treatments most often applied to influence its nutritional values (Premi et *al.*, 2010; Sallau et *al.,* 2012). Past study were showed that drying concentrates the leaves nutriments, facilitates its

conservation and its consumption (Joshi and Mehta, 2010; Moyo et *al.*, 2011). This work aims to study the effect of roasting on the nutritional value of the *Moringa oleifera* leaves.

Material and Methods:-

Vegetable material

The *Moringa oleifera* leaves used were come from the Agronomic Faculty of Science farm in the University of Abomey Calavi (UAC) Benin.

Methods

Leaves treatment and operation of roasting

The flow chart of Figure 1 summarizes the whole of the operations carried out on *Moringa oleifera* leaves used.

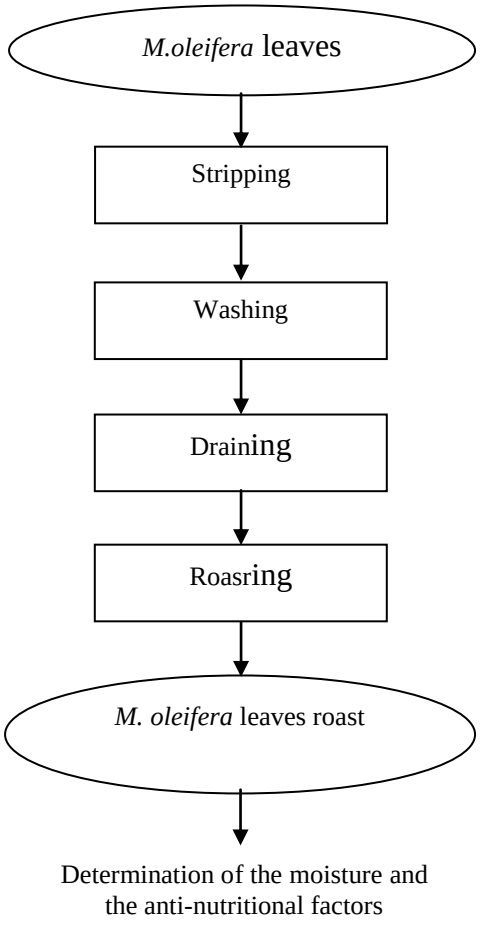

Figure 1: Flow chart of the operations carried out on the *M. Oleifera* leaves

These operations consist on the preparation of the leaves before roasting. The leaves of *M. oleifera* were leafless by separating the leaflets from their petiole. At this level the leaves having undergone a yellowing, an infection or an unspecified deterioration are eliminated. The leaflets were washed with drinking water to eliminate the foreign bodies. Then, they were washed again with a potassium permanganate solution (1: 10) during 3 to 5 minutes, in order to remove them from the germ, then abundantly rinsed with drinking water. Finally they were drained using a strainer.

The roasting was led on hotplate using a centered composite experimental plan to two factors in order to optimize its effect on the anti-nutritional factors. The roasting duration (t, 20-120 minutes) and the temperature (T, 50-100 °C)

are the variables of orders of the process. A total of 13 tests was obtained with this plan. Each test is carried out in three repetitions. This treatment was applied to 20g of fresh leaves for each stage of temperature.

Factors of answer and analytical methods

The water content and volatile matters, oxalate, phytate and total phenols are the factors of answer retained to evaluate the influence of roasting on the anti-nutritional factors of the roasting *M. oleifera* leaves. The water content and matters volatile is the loss of mass undergone by the sample after heating with 103 ± 2 °C, under the specified conditions of international standard NF 60-201 or normalizes ISO 662 and expressed as a percentage mass. The proportioning of the phytates was carried out according to the method of Reddy and Love (1999). The total oxalate was proportioned by the method of Day and Underwood (1986). The method of Folin-Ciocalteu (Singleton et *al.*, 1999) was used to determine the content of phenolic compounds. The preliminary results havingshown that the influences of these two variables on the response variables (Y) is not linear, it was modelled in the polynomial form of second degree ($Y= b_0 + b_1t + b_2T + b_3 t^2 + b_4 T^2 + b_5t.T$). Signs of the coefficient, the linear terms (b_1, b_2), quadratic (b_3, b_4) and the interactions (b_5) allow put in obviousness the synergic effects (sign +) and antagonist (sign -) of the order variables on the answer. The term b_0 represents the coefficient of central points.

Statistical data processing

The results obtained were statistically treated by variances analysis in order to estimate the influences of the order variables on the answers observed. The tests of multiple regression and the layout of the curves iso-response made it possible to develop mathematic model to express the results. MINITAB 14 so ftware was used for this purpose. The models considered to be satisfactory are those present a coefficient of regression (R^2) superior to 0,75 (Henika, 1982).

Result and Discussion:-

Linear multiple regression coefficients and variance analysis of the models suggested ($Y = b_o+b_1 t + b_2 T + b_3 t^2+b_4 T^2+b_5t.T$) for the water content, of oxalates, total phenols, and phytate according to the composite experimental design centered are presented in table 1.

Table 1: Multiple linear regression coefficients and model of analysis of variance

Coefficients	Moisture	oxalate	phytate	Phenolic compounds
b_1	-1.108^{*}	-0.236^{*}	-0.209^{**}	-0.425^{**}
b_2	-1.635^{*}	-0.825^{*}	-0.349^{**}	-0.198^{*}
b_3	-1.108^{NS}	0.380^{NS}	0.041^{**}	0.068
b_4	-0.789^{NS}	-0.371^{NS}	0.303^{**}	-0.014^{NS}
b_5	-0.039^{NS}	0.375^{*}	0.031^{NS}	-0.122
b_o	11.869	3.069	0.248	2.288
R^2	99	88.2	98.1	82.1

**: p < 0.01 ; *: p < 0.05

Influence of temperature and duration of roasting on the water content.

The iso-response curve (Figure 2) represented the variation of the water content (%) of the *M. oleifera* leaves in function of the temperature and the roasting duration. The increase in the temperature from 50 to 100°C during 20 to 120 minutes involves a variation of the water content from 14.31 to 6.43%. Weakest water content were obtained for the extreme values of roasting duration and temperature. This variation of the water content is expressed bythe model $Y_1(t,T)$ of second following order:

$Y_1(t,T) = 11.8692 – 1.1082\ t – 1.6346\ T – 0.653\ t^2 – 0.7886\ T^2 – 0.0387\ t.T$ (% bs).Where t is the roasting duration and T the temperature of roasting.

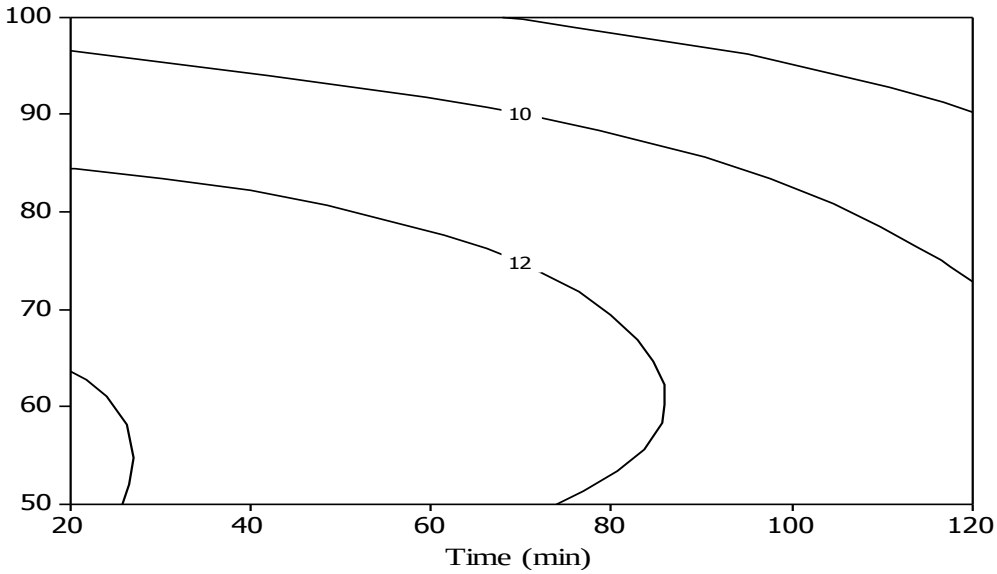

Figure 2: Iso-response curve showing the variation of moisture (g/100g bs) in function of roasting duration and temperature.

This model translates a good adequacy with the experimental phenomenon (R^2 =99%) studied. The variance analysis (ANOVA) of the regression model shows that linear and quadratic terms of roasting duration as well as their interaction have a significant antagonistic effect ($p < 0.05$) on the water content of the *M. oleifera* leaves. This could be explained by a dehydration (water loss) of the leaves during roasting; this dehydration is more marked by a simultaneous increase in roasting and temperature duration. The water content values were comparable with those (9.53%) obtained by Moyo et *al.* (2011) for *M. oleifera* dried leaves. Joshi and Mehta (2010), within the framework of the study of the effect of dehydration on the food value of *M. Oleifera*, obtained a water content of approximately 6% for the dried leaves at ambient temperature and with the furnace with 60°C during 5 hours.

Influence of roasting duration and temperature on the oxalate content of the leaves.

The experimental data processing by multiple regression, of the oxalate content in the *M. Oleifera* leaves, made it possible to develop the model to simulate the evolution of this response into function of the order variables. This evolution is represented by the model $Y_2(t,T)$ of second order whose curves of equal content oxalate are represented by figure 3:

$Y_2(t,T) = 3.0690 – 0.2357t – 0.8250T + 0.3793t^2 – 0.3707T^2 – 0.3750\ t.T$(% bs) Where t is the roasting duration and T the roasting temperature.

This model explains 88.2 % of the variation of the oxalate content in the roasting leaves. The analysis of the variance shows that linear terms of the roasting duration and temperature as well as their interactionhas an antagonistic effect on the oxalate content (varies from 0.54 to 2.4 g/100g bs). The increase in the roasting duration influences considerably the oxalate content as well as at low temperatures than high. This report was also made by Gonzalo (2008) on soya beans. The oxalate contents obtained are lower than that (4.1%) obtained by Foild et *al.*, (2001) on the fresh *M. Oleifera* leaves, but comparable (0.63 g/100 bs) with that obtained by Tchiégang and Aissatou (2004) for leaves *M. oleifera* dried.

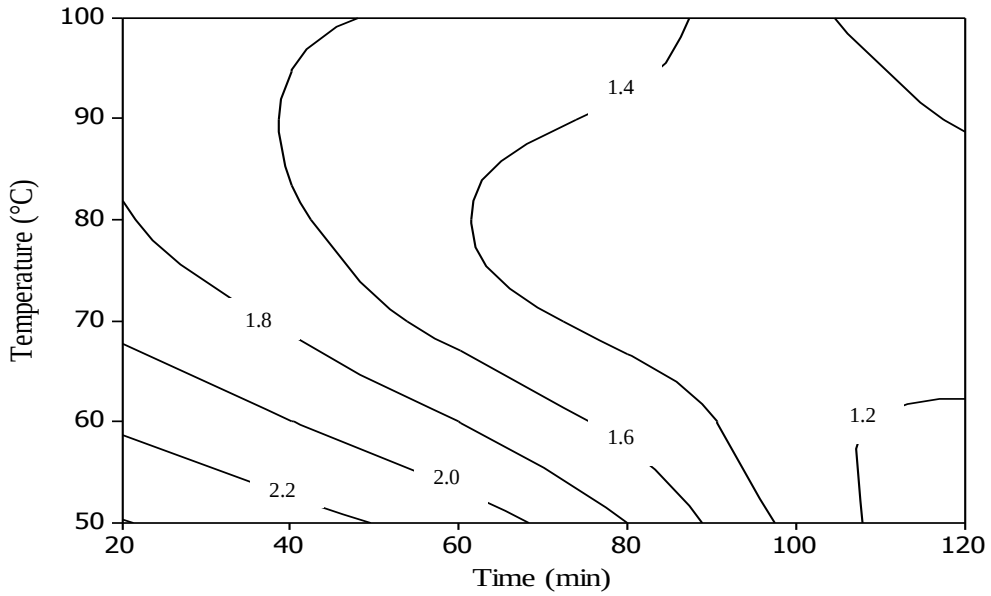

Figure 3: Iso-response curve showing the variation of the oxalate content (g/100g ms) as the function of the roasting temperature and duration.

Influence of temperature and duration on the phytate content of roasting leaves

The influence of time and the temperature on the phytate content of the *M. oleifera* leaves is represented on figure 4. This iso-response curve explains 84% of the variation of the phytate content (from 0.15 to 1.87g/100g in dry base). The regression model related to the two factors (duration and temperature) is represented by the following equation: $Y_3(t,T) = 0.2474 - 0.20888\ t - 0.34949\ T + 0.04109\ t^2 - 0.30291\ T^2 - 0.03125\ t.T$ (% bs) Where t is the roasting time and T the roasting temperature.

The linear, quadratic terms as well as the interaction of these two factors have significant antagonistic effects ($p < 0.05$) on the phytate content. The analysis of the iso-response curve (Figure 4) shows that at constant temperature, the increase in the roasting duration involves a fast reduction in the phytate content. On the other hand this reduction is slower according to the roasting duration and temperature given. The effect of the roasting temperature gradient on the phytate content is more perceptible than that of the roasting duration. An increase in the temperature and roasting duration are accompanied by a reduction in the phytate content. The lowest phytate contents (< 0.3g/100g in base dries) are obtained for powder samples of *M. oleifera* roasting during at least 40 minutes at temperatures lain between 70 and 80°C. These values are inferior (2.45%) than that obtained by Foild et *al*. (2001) on the *M. oleifera* leaves. According to works of Sallau et *al.* (2012), the heat treatments such as boiling and bleaching reduce respectively of 85.44% and 39.80% the contents of phytate of the fresh leaves. This was also observed by Adekanmi et *al.* (2009) on the galingale. It observes that roasting at 120°C reduce from 22 to 40% the phytates content of galingale and notes more marked reduction when the roasting duration varies from 10 to 30 minutes.

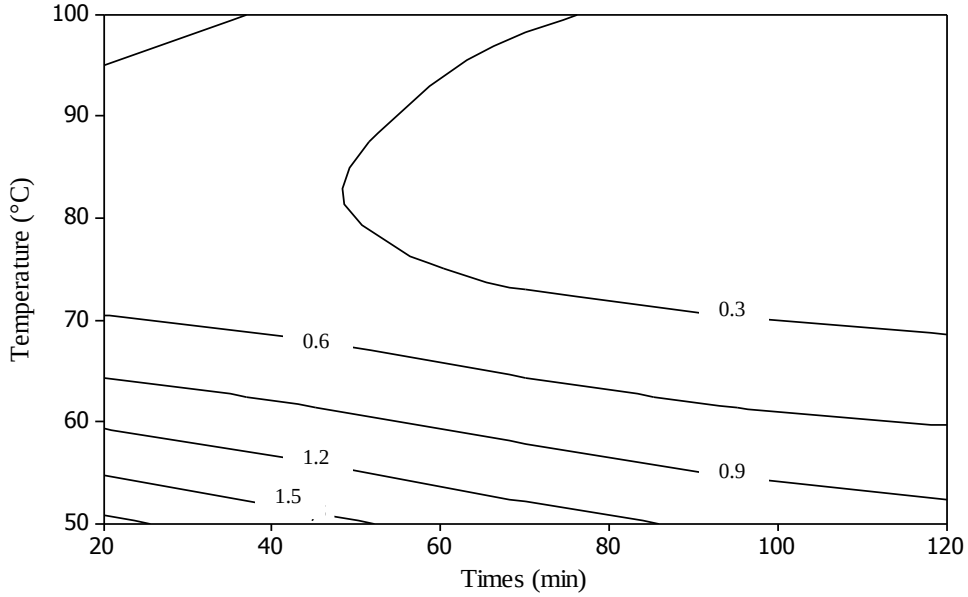

Figure 4: Iso-response curve showing the variation of the phytate content (g/100g ms) as the function of the temperature and of roasting duration.

Influence of temperature and duration on the content of phenolic compounds of the roasting leaves.

The variation of the totals phenol content (Y_4) as the function of the temperature and of the roasting duration is shown in the following equation:

$Y_4(t,T) = 2.28228 – 0.42544\ t - 0.19799\ T + 0.06802\ t^2 – 0.01448\ T^2 – 0.122507\ t.T$ (% bs).Where t is the time of roasting and T the temperature of roasting.

This model explains 82.1% of the variation of the phenol content, which decreases from 3.2 to 1.21 g of gallic acid/100 g in dry base. Figure 5 illustrates the variation of the content phenol of the *Moringa* leaves according to the temperature and of the roasting time. The analysis of this iso-response curve reveals that the linear terms of the temperature and the roasting duration as their interaction have a negative influence on the phenols total content of the leaves *M. oleifera*. It is noted that at a given temperature, an increase in the time of roasting involves a reduction of the total phenols content. Also, one observes the same phenomenon, at a time of torrefaction given with variation in the temperature of torrefaction. In the same way, the simultaneous increase in the two parameters (temperature and time of torrefaction) led has a significant reduction in the content total phenols.

The lowest contents phenols (< 1.5% of gallic acid) are obtained for temperatures higher than 65°C after at least 90 minutes of roasting. The contents of total phenols (1.21 and 1.7% of gallic acid) are obtained at a temperature of 100°C respectively during 70 minutes and 120 minutes of roasting. These results lower than that (2. 02%) from Moyo *et al.* (2011) after drying in the shade of the leaves of *M. oleifera*. Also, its low content are comparable with that of 1.6%, obtained by Foild et *al.* (2001).

The data obtained on the roasting leaves result in the reducing effect of the heat treatments on the anti-nutritional factors. This phenomenon was observed by Adekanmi *et al.*. (2009). El-Hady and Habiba (2003) noted a reduction in several anti-nutritional factors of which total phenols in the extrudats of pea and chickpea broad bean (*Vitiated faba L.*), common bean *(Phaseolus vulgaris L).*

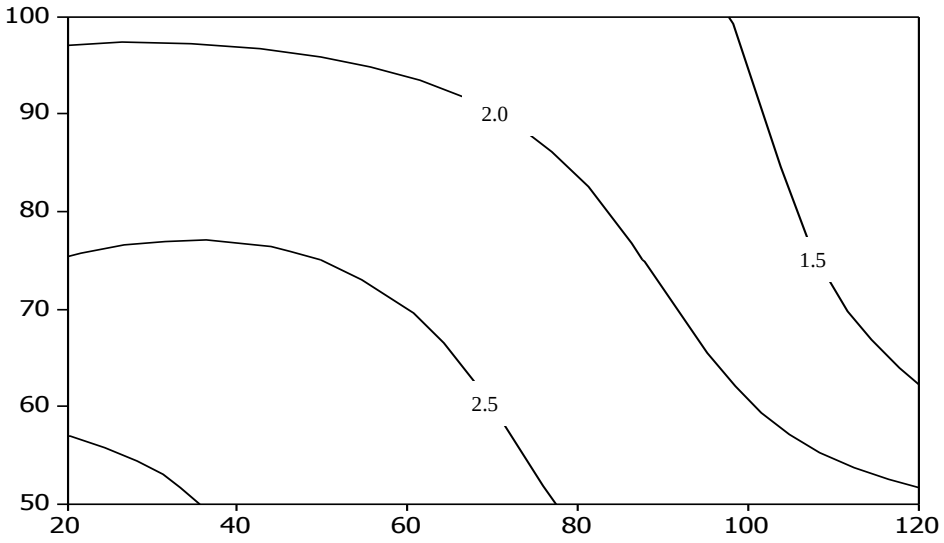

Figure 5: iso-response curve showing the variation of the totals phenol content (% of acid gallic) as the function of the temperature and the roasting duration.

Conclusion:-

This work enabled us to study the effect of roasting on the *M. oleifera* leaves. The method used is that of surfaces of response through the composite plan centered to two factors (temperature and time). It enabled us to analyze their influence and their interaction on the content of anti-nutritional factors contained in the leaves of *M. oleifera.* Thus, the significant reduction in the content of oxalates, phytates and out of phenols observed during roasting is narrowly a function of the increase in the temperature and the duration of this heat treatment. The low values in the anti-nutritional factors were obtained at high temperatures of roasting. This reduction of the anti-nutritional factors has a considerable nutritional importance since it induces by rebound an increase in the bio-availability of the nutriments necessary to the health of the consumers.

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