Full Length Research Paper

**Physico-chemical and microbiological characteristics of dried Waragashi**

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In this study, effects of drying temperature on the physico-chemical and microbiological characteristics of Waragashi were investigated. Three types of produced Waragashi were investigated. The first one (V1) was obtained after coagulation of milk, the second called coloured Waragashi (V2), was obtained by boiling V1 for three minutes in aqueous solution of *Sorghum vulgaris* panicle (15 g/L) and the third one, refined Waragashi (V3) was obtained by boiling for three minutes, the Waragashi V1 into aqueous solution of *S. vulgaris* panicle (15 g/L), salt (10 g/L) and potash (3 g/L). The three fresh Waragashis contained 64.26, 57.34 and 54.04% moisture, respectively, for white Waragashi (V1), colored Waragashi (V2) and refined Waragashi (V3), while dried samples varied between 12.28 and 15.57%. The corresponding dried Waragashi were firmer than the fresh ones. Moreover, the colored cheeses (V2) were firmer (60.08 ± 5.40N and 206.4 ± 13.70 N) than the refined one (38.57 ± 3.10 N and 55.89 ± 5.89 N). After 48 h of drying, all samples showed a decrease of micro-organisms (mesophilic total bacteria, lactic bacteria, yeasts and moulds, *Enterobacteria* and *Staphylococcus* spp.) counts. However, drying at 45°C preserve more the physico-chemical characteristics of Waragashi.

**Key words:** Waragashi, cheese, drying, physico-chemical characteristics, microbiological quality.

**INTRODUCTION**

Due to the difficult conservation of the fresh cow’s milk in developing countries, attempts of technological approaches were developed to transform it into added value products (Dossou et al., 2006). The production of cheeses provides a useful service by extending the shelf life of a valuable human foodstuff-milk. Waragashi is Benin local dairy product that is widely consumed in rural as well as suburban and urban zones. The lack of standard processing methods explains the variations observed in quality of Waragashi in the different areas of production (Turkoglu et al., 1987, Belewu, 2004).

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Waragashi is an excellent source of protein, fat and minerals (calcium, iron and phosphorous), vitamins and essential amino acids. It is often consumed as a substitution to the meat and fish in various dishes (Kees, 1996).

In spite of its economic and nutritional importance, it is difficult to preserve Waragashi for a long time. Common traditional methods applied for preservation did not extend efficiently its shelf life. In order to increase the shelf life of Waragashi, a study on the preservation of this product by evaluating the effect of drying and vacuum packaging was carried out (Sacramento, 2008). As a result, Waragashi can be preserved during two months. However, the cost of the product makes the implementation of developed process difficult in economical point of view. Another work in Nigeria on wara cheese conservation focused on the effect of short-term frozen storage on the chemical composition and coliforms microflora was reported (Alalade and Adeneye, 2006).

It is well known, that the drying foods, preserves the shelf life of the products as well as the nutritive value and produces a new flavor (Shikha and Usha, 2012). In spite of the popularity of Waragashi in West Africa areas, few studies on appreciation of physico-chemical, technological and microbiological characteristics of dried Waragashi produced in Benin were investigated. The aim of present work was to evaluate the effect of temperature on physico-chemical, technological and microbiological characteristics of Waragashi cheese after drying.

MATERIALS AND METHODS

Preparation and drying of Waragashi

The milk used for the manufacture of Waragashi was collected at a Peuhl camp at Abomey-Calavi. The collected cow milk was stored immediately in isothermical box containing ice in order to suppress the increase of microorganism population. The Waragashi was prepared according to the process developed by Dossou et al. (2006). The Calotropis procera leaves obtained from the University of Abomey-Calavi grounds were used to prepare the coagulant solution as describe by Dossou et al. (2006). The Sorghum vulgaris panicle, the potash and salt were bought in a market of Godomey (Benin) and were used to color Waragashi. The produced Waragashi was drained and shaped on cylindrical box. The weight of the matrix was determined before and after 30 min of drainage with a portable electronic balance (Acculab Sartorius Group, Edgewood, NY, USA). Each Waragashi drained was cut into four parts and regrouped into three batches: the main one (Variety 1: V1), the coloured Waragashi (Variety 2: V2) and the refined Waragashi (Variety 3: V3).

The Waragashi V2 was obtained by boiling for three minutes the Waragashi V1 into aqueous solution of S. vulgaris panicle (15g/L) while the Waragashi V3 was obtained by boiling for three minutes the Waragashi V1 into aqueous solution of S. vulgaris panicle (15 g/L), salt (10 g/L) and potash (3 g/L). The three batches of Waragashi were closely followed during drying into electric oven (D 06060, model 400; MEMMERT, W 8540 Schwarbach, Gmbh + CoKCT). The thermic drying at hot air was made into two temperatures during 48 h: 45°C (temperature 1: T1) and 60°C (Temperature 2: T2) through two batches. In total, 20 samples of Waragashi by batch were analyzed for physico-chemical, physical and microbiological analysis before and after 48 h of drying. The kinetics of the water loss vs. time was determined by the “drying characteristic curve” (DCC), which represents the drying rate V(t) as a function of reduced water content \( \Phi \). These two variables are defined as described by (Ahouanou et al., 2000):

\[
\Phi = \frac{X(t) - X_{eq}}{X_{cr} - X_{eq}} \quad \text{and} \quad V(t) = -\frac{dX}{dt}
\]

where, X(t): Dry basis product water content at time t, \( X_{eq} \) dry basis product water content when equilibrium between air and product is reached, \( X_{cr} \) dry basis product water content at the head of the first drying phase (initial phase with constant drying rate), V(t): drying rate of product at time t, \( V_{0} \): drying rate of product during the first drying phase.

A mathematical expression of DCC for a product with specific initial dimensions is sought through the analysis of experimental drying curves obtained with different conditions of temperature, humidity and air drying speed. A representative example of such curves is shown in Figure 3, for the case of biological products. According to Jannot et al. (2002), the phase of raising temperature phase is most often negligible, especially if the difference between the air temperature and the product is low; and if the dimensions of the product are also low. Our experimental results are in concordance with this hypothesis.

The experimental curves X(t) have been derived to obtain the estimated curves \( \bar{V}(t) = ( -\frac{dX_{cr}}{dt} )t \). Such analysis gives a mean value of the critical water content \( X_{cr} \) as shown in Figure 3. Several authors, among them, Desmorieux and Moyné (1992) have considered that for biological products it is difficult to identify a critical water content different from the initial water content \( X_{0} \). Thus, it is assumed equal, \( X_{cr} = X_{0} \).

Physico-chemical analysis

Total solids content, ash and acidity were determined according to the methods described by AOAC (1990). Total sugar was determined according to the methods described by Dubois et al. (1959). Cheese samples were analyzed for pH values by using a digital pH-meter (Hanna Instruments, Model HI 98129, Singapore). The fat was extracted from cheese in a Soxlet extractor with petroleum ether according to the methods described by Bligh and Dyer (1959) and Hubbard et al. (1977). The fat content was gravimetrically measured after the remotion of the solvent by rotary evaporation under vacuum (Bligh and Dyer, 1959). All physico-chemical analysis tests were conducted in triplicate.

Physical analysis

The texture was determined using a Stevens LFRA Texture Analyser (TA Instruments, USA) (Cayot et al., 2009) and the color through a chromameter Minolta Chroma CR-210 b (Minolta Camera Co. Ltd, Osaka, Japan). Analyses were done in triplicate.

Microbiological analysis of milk and various types of Waragashi

The analyses were achieved both on the milk and Waragashi. The count of mesophilic total bacteria, lactic bacteria, coliform bacteria, yeasts and moulds, and Staphylococcus spp. were evaluated. The plate count agar was used for the mesophilic total bacteria count.
Table 1. Physico-chemical characteristics of milk.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>x ± SD&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative density</td>
<td>1.02 ± 0.01</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>87.60 ± 0.37</td>
</tr>
<tr>
<td>pH</td>
<td>6.78 ± 0.05</td>
</tr>
<tr>
<td>Total acidity (%)</td>
<td>0.19 ± 0.02</td>
</tr>
</tbody>
</table>

<sup>a</sup>Means of three independent trials ± standard deviation (SD).<sup>b</sup>The water content was given in three replications according to the thermogravimetric method for the determination of the water content in food according to standard AOAC (1990).<sup>c</sup>Total acidity by titration with NaOH 0.05 N until the indicator turn pink.

(Multon et al., 1994). The Man Rogosa Sharp medium (ISO 15214: 1998 (F)) was used for the lactic bacteria, the Malt Extract Agar (ISO 7954: 1987 (F)) for yeasts and moulds, the Violet Red Bile Agar for coliform bacteria count, according to the V 08-020 (1994)/ISO 7251 and V 08-021 (1993)/ISO 7402 norms (Bourgeois et al., 1989) and the Baird-Parker agar was used for Staphylococcus spp. count. For all microbiological analyses, samples of 25 g were taken from the cheese, transferred into 225 ml of the peptone water (% w/v) and homogenized. From the initial dilution, appropriate decimal dilutions were prepared and aliquots were plated in duplicate in the different mediums.

**Mesophilic total bacteria count**

One milliliter of each dilution was placed into each box after homogenization. 15 to 20 ml of the Plate Count Agar were smoothly added and kept at 45°C ± 0.5 (Multon et al., 1994). After the solidification, the box was turned over and incubated at 30°C during 72 h.

**Lactic bacteria count**

One milliliter of each dilution was inoculates into each Man Rogosa Sharpe box (ISO 15214: 1998 (F)). The incubation was done at 30°C for three days.

**Yeasts and moulds count**

The selectivity of the malt extract agar was changed with the addition of lactic acid at 10% (sterilized previously at 121°C during 15 min) using a relationship of 100:2 ml. The incubation was done at 25 ± 1°C for 5 days (ISO 7954: 1987 (F)).

**Coliform bacteria counts**

From the decimal dilutions taken from 10<sup>−1</sup> to 10<sup>3</sup>, 1 ml in two boxes was introduced aseptically in two. About 20 ml of the Violet Red Bile Agar was added to the content of each boxes, melted and cooled at 45 ± 1°C. The mixture was homogenized by a circular movement. A range of box was incubated at 30°C during 24 - 48 h so as to detect the total coliform and a second range is incubated at 44°C during 24 - 48 h to detected the fecal coliforms (Bourgeois et al., 1989).

The boxes incubated at 44°C were recovered; the germ that they contained was streaked onto Eosine Methylene Blue (EMB) and incubated at 37°C during 24 h in order to detect E. coli.

**Staphylococcus spp. count**

0.1 ml of each dilution was inoculated onto the surface of the Baird-Parker agar, incubated at 37°C in aerobic conditions and the examination was achieved after 24 and 48 h.

**Statistical analysis**

The data obtained from these studies were analyzed using Statistical Analysis Software (SAS) and SPSS 17 (SPSS Inc. 233 South Wacker Drive, 11th Floor Chicago, IL 60606-641). The statistical analyses carried out were mean, standard deviation and analysis of variance (ANOVA) (Ogbeibu, 2005).

**RESULTS**

**Physicochemical and microbiological characteristic of milk**

Tables 1 and 2 show, respectively, the physicochemical and microbiological characteristic of the milk. The relative density (1.02 ± 0.01), the moisture (87.60 % ± 0.37), the pH (6.78 ± 0.05) and the total acidity (0.19 % ± 0.02) are very close to that listed in NF ISO 11816-1 (87%, 1.020 and 6.78, respectively for moisture, relative density and pH). The average of lactic bacteria, yeasts and moulds, Enterobacterias and Staphylococcus spp. counts for milk were determined and were, respectively, 5.30, 6.30, 1 and 0 log (CFU/ml), respectively, whereas the value of the mesophilic total bacteria count was lower (2.47 log CFU/ml) (Table 2). The mesophilic total bacteria and Enterobacterias counts were in concordance with the Institut Sénégalais de Normalisation (ISN) (1988) and Agence Française de Normalisation (AFNOR) (1976) criteria. However, the value of mesophilic total bacteria count found was higher than that advisable for commercialized milks by ISN (1988). Moreover, the negative results obtained from both tests of white side and blue methylene may confirm the good quality of the milk for the production of Waragashi.

**Physico-chemical characteristics of Waragashi**

Tables 3 and 4 show the characteristics of Waragashi produced (V1, V2 and V3) and the drying one (V1T1, V2T1, V3T1, V1T2, V2T2 and V3T2). The moisture content of Waragashi produced was 64.26, 57.34 and 54.04% respectively, for white Waragashi, coloured Waragashi and refined Waragashi (Table 3). Dried samples varied between 12.28 and 15.57%. As observed, during the analysis, the total sugar content of all Waragashi was statistically invariable and showed
### Table 2. Microbiological quality (log CFU/ml)\(^a\) of milk.

<table>
<thead>
<tr>
<th>Microbiological quality</th>
<th>Mesophilic total bacterial count</th>
<th>Lactic bacteria count</th>
<th>Yeasts and moulds count</th>
<th>Enterobacteriolar count</th>
<th><em>Staphylococcus</em> spp. count</th>
<th>White side test</th>
<th>Blue methylene test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk used</td>
<td>&lt; 2.47</td>
<td>5.30 ± 0.34</td>
<td>6.30 ± 0.34</td>
<td>1.00 ± 0.00</td>
<td>Absence</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Microbiological criteria (ISN, 1988)</td>
<td>4.30</td>
<td>*</td>
<td>*</td>
<td>2</td>
<td>Absence</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

*Conformity* | Conform | - | - | conform | conform | - | - |

\(^{a}\)Absence of criterion; -: Disregarded; \(^{b}\)Means of two independent trials (log CFU/ml) ± standard deviation (SD).

I.S.N. (Institut Sénégalais de Normalisation).

### Table 3. Physico-chemical characteristics\(^*\) of Waragashi.

<table>
<thead>
<tr>
<th>Waragashi</th>
<th>Dry matter (%(^d))</th>
<th>pH</th>
<th>Total Acidity (%db(^e))</th>
<th>Total Sugar (%db(^f))</th>
<th>Ash (%db(^g))</th>
<th>Lipid (%db(^h))</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>35.74±0.11(^a)</td>
<td></td>
<td>6.70±0.00(^d)</td>
<td>0.12±0.00(^e)</td>
<td>5.75±0.11(^a)</td>
<td>2.06±0.04(^a)</td>
</tr>
<tr>
<td>V2</td>
<td>42.66±0.60(^b)</td>
<td></td>
<td>6.65±0.07(^c)</td>
<td>0.14±0.00(^f)</td>
<td>5.10±0.09(^a)</td>
<td>2.09±0.03(^a)</td>
</tr>
<tr>
<td>V3</td>
<td>45.96±0.05(^c)</td>
<td></td>
<td>6.60±0.14(^b)</td>
<td>0.15±0.00(^g)</td>
<td>5.64±0.08(^a)</td>
<td>2.17±0.06(^a)</td>
</tr>
<tr>
<td>V1 T1</td>
<td>85.64±0.01(^d)</td>
<td></td>
<td>6.15±0.07(^a)</td>
<td>0.20±0.04(^h)</td>
<td>5.40±0.27(^a)</td>
<td>3.75±0.01(^b)</td>
</tr>
<tr>
<td>V2 T1</td>
<td>87.72±0.47(^f)</td>
<td></td>
<td>6.35±0.07(^b)</td>
<td>0.16±0.02(^i)</td>
<td>5.42±0.23(^a)</td>
<td>3.78±0.13(^b)</td>
</tr>
<tr>
<td>V3 T1</td>
<td>87.53±0.87(^f)</td>
<td></td>
<td>6.45±0.07(^b)</td>
<td>0.14±0.05(^j)</td>
<td>3.25±0.27(^a)</td>
<td>4.09±0.13(^b)</td>
</tr>
<tr>
<td>V1 T2</td>
<td>86.42±0.75(^e)</td>
<td></td>
<td>6.50±0.00(^b)</td>
<td>0.05±0.01(^k)</td>
<td>5.81±0.17(^a)</td>
<td>4.66±0.12(^c)</td>
</tr>
<tr>
<td>V2 T2</td>
<td>85.04±0.51(^d)</td>
<td></td>
<td>6.40±0.00(^b)</td>
<td>0.07±0.00(^l)</td>
<td>2.57±0.10(^a)</td>
<td>4.54±0.08(^a)</td>
</tr>
<tr>
<td>V3 T2</td>
<td>84.43±0.98(^d)</td>
<td></td>
<td>6.45±0.07(^b)</td>
<td>0.13±0.00(^m)</td>
<td>2.60±0.14(^a)</td>
<td>4.67±0.05(^c)</td>
</tr>
</tbody>
</table>

\(^{*}\)Means of three independent trials ± standard deviation (SD). 1, 2, 3, … 5. Expressed as …

V1: White Waragashi, V2: Coloured Waragashi, V3: Refine Waragashi, V1T1: White Waragashi dry at 45 °C, V2T1: Coloured Waragashi dry at 45°C, V3T1: Refine Waragashi dry at 45°C, V1T2: White Waragashi dry at 60°C, V2T2: Coloured Waragashi dry at 60°C, V3T2: Refine Waragashi dry at 60°C. The mean values followed by same letter in the same column are not significantly different (p< 0.05).

### Table 4. Physical characteristics of Waragashi.

<table>
<thead>
<tr>
<th>Waragashi</th>
<th>(L^*) (brightness)</th>
<th>(a^*) (red indicator)</th>
<th>(b^*) (yellow indicator)</th>
<th>Strength (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>88.79±0.88</td>
<td>-1.98±0.042</td>
<td>13.12±0.49</td>
<td>7.01±0.48</td>
</tr>
<tr>
<td>V2</td>
<td>43.78±1.82</td>
<td>42.24±0.39</td>
<td>31.39±1.18</td>
<td>10.38±1.31</td>
</tr>
<tr>
<td>V3</td>
<td>37.49±1.19</td>
<td>32.98±0.72</td>
<td>19.63±0.73</td>
<td>10.2±0.13</td>
</tr>
<tr>
<td>V1T1</td>
<td>61.46±0.87</td>
<td>-2.89±0.22</td>
<td>13.63±1.15</td>
<td>43.58±4.92</td>
</tr>
<tr>
<td>V2T1</td>
<td>31.21±1.24</td>
<td>26.10±0.78</td>
<td>14.23±1.35</td>
<td>60.08±5.40</td>
</tr>
<tr>
<td>V3T1</td>
<td>26.41±0.815</td>
<td>17.03±0.76</td>
<td>4.03±0.84</td>
<td>38.57±3.10</td>
</tr>
<tr>
<td>V1 T2</td>
<td>59.63±0.91</td>
<td>4.10±0.56</td>
<td>34.22±0.74</td>
<td>181.33±15.2</td>
</tr>
<tr>
<td>V2 T2</td>
<td>31.22±0.75</td>
<td>25.10±1.18</td>
<td>20.78±0.43</td>
<td>206.4±13.70</td>
</tr>
<tr>
<td>V3 T2</td>
<td>26.57±0.59</td>
<td>19.23±0.23</td>
<td>5.11±0.45</td>
<td>55.89±5.89</td>
</tr>
</tbody>
</table>

\(^*\)Probability; (***) = great variability (level: 1%) in the same column.

On the other hand, the total acidity content of the produced Waragashi (V1, V2 and V3) was statistically equal to that of the dried sample at 60°C. The total acidity content of the Waragashi varied between 0.12 and 0.15 % (db), the samples dried at 60°C varied between 0.05...
and 0.13% (db). The ash content of the Waragashi (V1, V2 and V3) was statistically equal and varied between 2.06 and 2.17% (db). Likewise, the ash content of the dried samples were statistically equal and varied between 3.75 and 4.09% (db) and between 4.54 and 4.67% (db) for the dried samples at 45 and 60°C, respectively. As clearly shown in Table 3, the lipid content of Waragashi varies accordingly with the variety and the drying temperature.

The results of the texture and the color characteristics of fresh and dried Waragashi (Table 4) showed a great variability (level: 1 %) between the two types of cheese. Meanwhile, Waragashi V1 had a great brightness (88.79±0.88), low red indicator (-1.98±0.042) and low yellow indicator (13.12±0.49). This cheese is less firm (7.01 N) than the colored (10.38 N) and the refine (10.2 N) ones. The colored sample was redder (42.24±0.39) and lighter (43.78±1.82) than the refined sample (32.98±0.72, 37.49±1.19, respectively for red indicator and brightness).

The brightness of dried sample varied between 59.63 and 61.46 for Waragashi V1 dried at 45 and 60°C, while those from V2 and V3 varied between 26.41 and 31.22. On the other hand, the dried cheeses were firmer than the fresh one.

Moreover, colored cheeses (V2) were firmer (60.08±5.40 and 206.4±13.70) than that of the refined one (38.57±3.10 and 55.89±5.89) at 45 or 60°C.

**Kinetic of drying**

Figures 1, 2 and 3 present the kinetic of reduced moisture of Waragashi, the kinetic of drying speed of
Waragashi and kinetic of evolution of drying speed of samples. From the results of the Figures 1a and b, the plots are leading as typically observed on biologic product like food. The plot present two principal phases, in the first part, corresponding to the 24 h of drying, the moisture decreased rapidly followed by a less fast decreased phase. The average moisture of fresh samples and dried one at 45°C (Figure 1a), respectively, were 1.837 and 0.147 g water/g DM (db) for white cheese, 1.684 and 0.129 g water/g DM (db) for colored cheese and 1.595 and 0.132 g water/g DM (db) for the refine one. However, statistically there is the significant difference (5%) between the declines of moisture of all samples from the eighteenth to forty-eighth hour at the end of drying. The average moisture of fresh samples and dried one at 60°C (Figure 1b) were 1.897 and 0.167 g water/g DM (db) for white cheese, 1.642 and 0.176 g water/g DM (db) for the colored cheese and 1.579 and 0.201 g water/g DM (db) for the refine sample.

Static analyses showed a significant difference (5 %) between the declines of moisture of all samples from 16 to 48 h by the end of drying. Figure 2a and b show the evolution of the drying speed at 45 and 60°C of white, colored and refined Waragashi. During the 10 first min of drying at 45°C, no evolution was observed (Figure 2a) but after twenty minutes of drying, there was a maximal average of 0.0086 g water/g DM.min⁻¹ for Waragashi V1 and speed of 0.0080 g water/g DM.min⁻¹ for Waragashi V2 and V3. Later on, the speed began to decrease until the end of the process. However, the analysis of variance did not show a significant difference between the drying' speeds of the three cheeses from the beginning to the end of the process. The evolution of speed of each variety of cheeses was also investigated (Figures 3a, b and c). From the results of Figure 3, the average speed of the elimination of water was 0.006 g water/g DM x min⁻¹ for drying at 45°C and was 0.007 g water/g DM x min⁻¹ for 60°C.
Table 5. Microbiological quality (CFU/g)* of Waragashi fresh with respect to the Food Safety Consult (F.S.C.) (2005) criteria.

<table>
<thead>
<tr>
<th>Waragashi</th>
<th>Mesophilic total bacteria count</th>
<th>Lactic bacteria count</th>
<th>Yeasts and moulds count</th>
<th>Enterobacterias count</th>
<th>Staphylococcus spp. count</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>2.30 ± 0.21</td>
<td>3.30 ± 0.24</td>
<td>2.60 ± 0.24</td>
<td>1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>V2</td>
<td>1.78 ± 0.07</td>
<td>1.70 ± 0.18</td>
<td>1.30 ± 0.00</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>V3</td>
<td>1.70 ± 0.08</td>
<td>1.30 ± 0.24</td>
<td>1.48 ± 0.36</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>

Microbiological criteria:
* absence of criterion;
- disregarded;* Means of two independent trials (log CFU/ml) ± standard deviation (SD).

Level of conformity of the samples (%)
- 100

V1: White Waragashi, V2: Coloured Waragashi, V3: Refine Waragashi

Table 6. Microbiological quality (CFU/g)* of Waragashi dried with respect to the AFNOR criteria (1994).

<table>
<thead>
<tr>
<th>Waragashi</th>
<th>Mesophilic total bacterial count</th>
<th>Lactic bacterial count</th>
<th>Yeasts and moulds count</th>
<th>Enterobacterias count</th>
<th>Staphylococcus spp. count</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1 T1</td>
<td>&lt; 1.30</td>
<td>1.60 ± 0.11</td>
<td>1.70 ± 0.49</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>V2 T1</td>
<td>&lt; 1.30</td>
<td>1.60 ± 0.24</td>
<td>1.30 ± 0.24</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>V3 T1</td>
<td>&lt; 1.30</td>
<td>1.48 ± 0.17</td>
<td>1.00 ± 0.00</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>V1 T2</td>
<td>&lt; 1.30</td>
<td>1.48 ± 0.36</td>
<td>1.48 ± 0.24</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>V2 T2</td>
<td>&lt; 1.30</td>
<td>1.60 ± 0.43</td>
<td>1.00 ± 0.00</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>V3 T2</td>
<td>&lt; 1.30</td>
<td>1.48 ± 0.00</td>
<td>1.48 ± 0.36</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>

Microbiological criteria:
3 2 2 2 2

Level of conformity of the sample (%)
100 100 100 100 100


**Microbiological quality of Waragashi**

Table 5 shows the microbiological quality of the produced Waragashi. The average of mesophilic total bacteria, lactic bacteria, enterobacteria and yeasts and moulds counts for white Waragashi (V1) were 2.30, 3.30, 1 and 2.60 log(CFU/g), respectively, while *Staphylococcus* spp. counts were lower (1 log(CFU/g)). Roughly, there is a decimal decreasing of microorganism in pre-treated cheeses (V2 and V3) and, after 48 h of drying, all the samples present a decrease of microorganisms and were in concordance with AFNOR (1994) criterias (Table 6).

**DISCUSSION**

It is well known that during drying of foods, bio-chemical changes such as glycolysis, proteolysis, and lipolysis take place by the modification of composition of the product and enhancing the characteristics features to foods, especially the texture and flavour. The analysis of variance (Table 4) shows that the colored and the refined Waragashi (V2 and V3) were firmer (10.38 and 10.2 N, respectively) than the white cheese (p < 0.05). The variations observed may be due to the infiltration of the molecules of color in white cheese during coloration and refining.

In fact, the infiltration of these may form a film of solution which decreases the moisture content of white cheese from 64.26 to 57.34% after coloration by a gradient of density (Table 3). The use of salt and potash may concentrate coloring molecule and increase gradient of density. This observation justifies the decrease of moisture of refined cheese (54.04%).

The decrease of moisture is physically expressed by the firmness of Waragashi as reported in several works in the literature (Mazou et al., 2012). Mazou et al. (2012), Sacramento (2008) and Kora (2005) suggested that the use of salt and potash favored the decrease of moisture and increase the texture of the cheeses.

The colored cheeses had great red and yellow indicator
The temperature of 60°C (Figure 1) does not affect the speed of drying (Figure 2). As shown in Tables 5 and 6, the produced Waragashi showed lower mesophilic total bacteria and Staphylococcus spp. counts than those detected in the milk. This finding confirms the destruction of the micro-organisms by heat. On the other hand, the count of yeasts and moulds in Waragashi were higher than that recommended by the AFNOR (1976) norms, which maintain these counts at a level than 1 log(CFU/ml) (Guiraud and Galzy, 1980). During samples drying, significant decrease of germs was observed, as reported also by Sacramento (2008) on Waragashi drying. The increase of temperature inhibited the development of most germs, as observed in this work during storage of Waragashi.

**Conclusion**

The effect of the drying temperature (45 and 60°C) preserves the physico-chemical characteristics of Waragashi, and the multiplication of microorganisms. However, drying at 45°C preserve more the physico-chemical characteristics of Waragashi due to the fact that it maintains the physico-chemical and technological characteristics of Waragashi close to the fresh one.

**Conflict of interests**

The authors did not declare any conflict of interests.

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règlement 455/7).