African food tradition revisited by research

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African Food Tradition rEvisited by Research
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Summary

This task also aims at producing product samples that will be used as demonstration samples for European food or ingredients companies. Sometimes, European companies have been approached and invited to participate in the production of samples in collaboration with European partners of AFTER. Sensory analyses have been sometimes organized for comparison with standard European products.
This activity aims at identifying samples productions activities in Europe allowing food industrials and ingredients companies to access to technical specifications and problems related to these productions and then to raise their interest for testing new products and productions from African Countries in their proper companies.
Reproducibility in Europe of the same process conditions used in African Countries was sometimes not easy and the adaptation of the traditional processing conditions by introduction of modifications was sometimes necessary.
Sometimes, it was also important to use raw materials, foodstuffs and varieties coming from Africa for facilitating reproducibility.
This sampling activity has also allowed a confrontation between the product and European consumer in order to test the opportunity of consumption of such food products in Europe.

Methodology

During the AFTER project a lot of sample of all the products have been produced. For each category of products, and for each product, identification of production samples activities at both laboratory scale and pilot scale has been done.
This identification has been performed by working groups organized during the last AFTER meeting in Saly (Senegal). Each working group was dealing with one out of 3 groups of products.

Results

A matrix has been fulfilled and completed for each category of products and for each product gathering all necessary information about sampling activities which took place during demonstration activities of the project.
This information is including:

- ✓ Place of samples production
- ✓ Team involved in the samples production
- ✓ Dates of production
- ✓ Scale of production (laboratory or pilot scale)
- ✓ Technical specifications related to the samples productions
- ✓ Main problems encountered
- ✓ Contacts for more details

Products	Place	Team	Date	Scale (Laboratory or pilot scale)	Technical specifications - Main problems	Contacts
Bissap (*Hibiscus sabdariffa*)	France, Montpellier	CIRAD		pilot scale	Produced from the functional ingredient : mayonnaise, nappage	
	France, Amiens	CVG	Numerous experiments between January 2013 and June 2014	Laboratory and micro-pilot scales (crude liquid concentrated extracts and spay-dried extracts). Chosen conditions: extraction at 25 °C with water (hydro-alcoholic extraction leads a 20-25 %better extraction rate and purity but is slower and unsafe for craft operation) and then simple filtration, concentration under vacuum up to 20 - 25 % dm. Optionally: microfiltration for sterilization and spray-drying up to 92-96 % dm.	Liquid concentrate and spray-dried powder: high in anthocyans at about 2,50 % dm - Main conclusions: slight differences between plant species (Koor and Vimto- preferred) and mainly between years, easy extraction, filtration and concentration (non-sticky nor foaming material), spray-drying successful without dextrins but to be confirmed on a larger scale in a long run. The unconcentrated extract (pH ≈ 2,0) is unstable, and anthocyans are sensitive to a pH rise, to light, and to temperature and oxygen to some extent (to be studied more carefully in various matrixes).	Philippe DAVID
Bouye/ Baobab pulp (*Adansonia digitata*)	France, Amiens	CVG	Storage experiments between January 2013 and June 2013	Laboratory scale	Ascorbic acid decay, browning and aroma degradation (bitterness) on storage: temperature seems the driving parameter at least in the first weeks. A tight packaging (oxygen and light proof) can only lead to a slight improvement under some circumstances.	Philippe DAVID
Jaabi (*Ziziphus mauritiana Lam.*)	France, Montpellier	CIRAD	April tu June 2013	pilot scale	Cf scientific paper in appendix.	Dominique PALLET

Table 1: **product samples for Group 3**

Bissap



Jaabi

Bouye (Baobab)

For this group of products, the samples production has been realized at laboratory and pilot scale.

No information about the involvement of food industrials and/or ingredients producers in these different samples productions has been transmitted.

Conclusions

For the group 3 of products, production activities of samples have been identified and collected all of them being performed at laboratory scale.
Technical specifications as well as problems encountered related to each sampling production activity are available for food industrials and ingredients producers in Europe interested in African food products and in diversifying their current production.

Annex: Project of publication on formulation and fabrication of Jujube cakes samples

Processed Z. mauritiana Lamk in the formula of high nutritional value cake

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Key words: jujube process, cake, phytochemical bioactivity, nutritional, polyphenols, vitamin C, rheological parameters, antioxidant

Highlights
Enhanced phytochemical compounds in jujube flour
Reviewed process leading to more nutritional cake
Optimization rheological parameters by steam oven
Postharvest diet valorization of jujube fruits

Abstract
The nutritional value of jujube fruits (*Ziziphus mauritiana* Lamk) was process reengineering through an optimized traditional cake making procedure. Initially, the characteristics of jujube fruit polysaccharides from an accession known as P3 were determined for each of the 5 ripening stages. Therefore, the content of the Alcohol Insoluble Materials (AIM), Water Soluble Polysaccharide (WSP) and Galacturonic Acid (GuAc) was determined at each ripening stage. The degree of methylation (DM) of jujube pectins was less than 50%, and so was classified as low methoxylated (LM) pectin. Using the 3rd and the 5th ripening stage to make the cake, the impact of the drying and cooking was evaluated on selected nutritional characteristics, including vitamin C, total phenolics content and antioxidant capacity. Remarkably, using the fruits from the 3rd stage, the drying process decreased the vitamin C content (74%) whereas an increase of 20 % was observed for the cake during the cooking step. Surprisingly, the antioxidant activity was unchanged during the drying process. In contrast, after the cooking process the phenolics content and the antioxidant capacity had both increased, by 64% and 30% respectively.
Overall, our results indicated that stage 3 fruits would exhibit higher nutritional qualities than stage 5 fruits. We strongly recommend stage 3 fruits of accession P3 for food applications, including jujube cake processing.

1. Introduction

The jujube fruit (*Ziziphus mauritiana* Lamk.), known as "*pomme surette*" in Guadeloupe, is underutilized despite its high nutritional value and its biological properties, underlined by various triterpenoid acids, flavonoids, phenolic acids, cytokinins and tannins **(Pawlowska, Camangi, Bader, & Braca, 2009)**. Furthermore, previous studies have revealed a high antioxidant capacity **(J.-W. Li, Fan, Ding, & Ding, 2007; Zhang, Jiang, Ye, Ye, & Ren, 2010; Zozio, Servent, Cazal, et al., 2014).**

Nevertheless, a huge range of food products have been established, including compotes, alcoholic beverages, flours, chutneys, pickles and some cakes in India **(Shobha & Bharati, 2007)**. However, rapid perishability is a problem for postharvest management and further processing **(Pareek, Kitinoja, Kaushik, & Paliwal, 2009).**

Depending on their ripening stages, the fruit skin color shifts from green to yellow, eventually reaching a reddish-brown color. Then, the harvested fruits can be classified into five ripening stages as showed in the previous work **(Zozio, Servent, Hubert, et al., 2014).**

A recent study on polysaccharides from *Ziziphus mauritiana* indicates that they have rheological properties **(Thanatcha & Pranee, 2011)**. High DM pectin (high methoxylated (HM), DM > 50%) can form a gel in acidic conditions in the presence of high sugar concentration. Conversely, gelation of low methoxyl pectin (LM, DM < 50%) occurs at higher pH in the presence of divalent ions, such as calcium, which acts as a bridge between pairs of carboxyl groups of different pectin chains. The main industrial sources for pectin extraction are apple pomace and citrus peels, which provide HM pectin. LM pectin can be obtained after chemical de-esterification of HM pectins. However, this process often induces pectin depolymerization, thus reducing the gel-forming ability of pectin **(Fraeye, Duvetter, Doungla, Van Loey, & Hendrickx, 2010)**.

Furthermore, polysaccharides extracted from plants and fungi have been identified for their anti-oxidative and hepatoprotective effect (**D. Wang et al., 2012**) and also for their immunobiological, anti-viral, anti-tumor and other biological activities **(García-González, Alnaief, & Smirnova, 2011**). Hence, the composition of polysaccharides from the species *Ziziphus jujuba* growing in China have been elucidated **(J.-w. Li, Ding, & Ding, 2007; J. Li, Shan, Liu, Fan, & Ai, 2011**).

In Africa, a traditional cake known as "yaabande" is made with harvested mature fruits and dry grains fallen from jujube trees onto the ground **(Dairou, Biyanzi, Pallet, & Ndjouenkeu, 2014)**. However, the ripening stage has not been clearly defined. Thus, in order to combine

processing and the biochemistry characteristics of jujube during the ripening, we evaluated the nutritional value of an optimized cake. Hence, we first characterized the polysaccharides during ripening in order to assess the rheological properties. Subsequently, we chose 2 ripening stages based on nutritional properties and the traditional processing method, to evaluate the impact of ripening on the quality of jujube cake, previously optimized. In addition, the impact of the process (drying and steam cooking) on the content of vitamin C, total phenolics and antioxidant capacity of the jujube cake was investigated. The optimized process was set as follows: drying parameters (45°C/30 h), size grading of jujube flour (465 µm) and cooking parameters (10 mins/ 100°C in a steam oven). The present investigation was carried out to help determine added-value uses of jujube fruits, and also to preserve this seasonal fruit for a longer period in flour and cake form. Our results strongly suggested that jujube fruits taken at stage 3 may provide high nutritional value and elevated antioxidant activity, in both the flour and the cake.

2. Material and methods

2.1. Fruit harvest and sampling

The cultivar P3 fruits were harvested in January 2012 on a local farm based in the south of the island under wild conditions, following the five ripening stage as described in the previous work **(Zozio, Servent, Hubert, et al., 2014).** The fruits were washed with 1% chlorinated water and rinsed with water. Then the fruits were stored for four days in air at 20°C in order to homogenize their internal temperature and to reveal any putative injured fruits that might not have been observed during harvesting. Ethylene production was measured in order to check the physiological stage of the fruit samples. The ripening stage 3 and 5 fruits were kept, the stage 2 fruits were matured until stage 3, and the stage 4 fruits until stage 5. Then 2 jujube lots were frozen before processing: stage 3 fruits were designated “3 fruits” and stage 5 fruits, as “5 fruits”.

2.2. Total soluble solids and titratable acid measurement

The fruits, flours or cakes were homogenized with a blender and centrifuged for 1 h at 10,000 × g and 4°C. The supernatant was collected for analysis of total soluble solids, pH and titratable acidity. The level of total soluble solids was determined using a digital Refracto 30PX/GS refractometer from Mettler Toledo, (Grosseron, Saint-Herblain, France). pH and

titratable acidity expressed as citric acid were determined by titration with 0.1N NaOH using a TitroLine easy apparatus from SCHOTT Instrument (Bioblock, Illkirch, France).

2.3. Determination of ascorbic acid content

Five hundred milligram of fruits, flours or cakes were stirred in 10 ml of methaphosphoric acid 4% for 10 mins, and then centrifuged for 10 mins at 10,000 rpm. The remaining supernatant was then filtered through a 0.45 µm filter (Millipore) and then analyzed by HPLC using a 1200 series HPLC Agilent System.

2.4. Determination of jujube flour grading

The particle size was determined by the Mastersizer 3000 laser diffraction particle size analyzer (Malven Instruments, Malvern, Worcestershire, UK) at a grinding speed of 1500 rpm. The mean of 6 measurements was used to estimate the particle size of 3 grading flours.

2.5. Determination of jujube cake firmness

Jujube cake firmness was measured by a texture analyzer (Stable Micro Systems TAXT PLUS). Preliminary experiments were conducted to optimize the process conditions with a ball probe adjusted for 70% deformation of the cake, with a speed of 0.7 mm/s. The force recorded in Newtons (N) was given as firmness. This measurement corresponds to the force needed to give a deformation of 70%. The more flexible the cake, the less it was deformed.

2.6. Total phenolics (TP) content

Total phenolics content was evaluated spectrometrically method using the Folin-Ciocalteu reagent as per the method of **Singleton, Orthofer, and Lamuela-Raventós (1999)** modified for a TECAN Infinite 200 96-well plate reader. Catechin was used as a standard to quantifying the TP content in fruits, flours and cakes. The results were expressed in mg catechin equivalent (CE) /100 g.

2.7. Antioxidant capacity determination

The FRAP assay was carried out on a TECAN Infinite 200 96-well plate reader (TECAN Austria GMBH) as per **(Zozio, Servent, Cazal, et al., 2014)**. Trolox was used as a standard to

quantify the TP content in fruits, flours and cakes. The results were expressed in mg Trolox equivalent (TE) /100 g.

2.8. Polysaccharide analysis

2.8.1. Extraction method

Polysaccharide extraction from jujube fruits was carried out as per the modified method based on **(J. Li, Fan, & Ding, 2011)**. Lyophilized jujube fruits were refluxed with 96% ethanol at 70°C for 1 h, and this step was repeated 3 times. Subsequently, the dried ethanol-extracted residue was extracted with distilled water at 80°C for 3 h. After one night of decantation at 4°C, the aqueous part was recovered by centrifugation (4°C/20 mins/10000g) and concentrated. The polysaccharide was isolated by mixing 3 volumes of cold 96% ethanol. The precipitate was recovered by centrifugation (4°C/20 mins/ 10000g), and finally lyophilized. Brown water-soluble polysaccharide (WSP) was obtained.

2.8.2. Galacturonic acid content

A method based on **(Chang, Hsu, & Chen, 2010)** was modified to determine galacturonic acid content. Five milligrams of polysaccharide from each ripening stage was poured into a screw-capped tube, then 1 ml of sulfuric acid was added for hydrolysis for 3 h at ambient temperature. After dilution and filtration thought gauze, 500 µl was mixed thoroughly with 2.5 ml of 0.125M sodium tetraborate in sulfuric acid and immediately cooled in an ice-bath. Then, all the tubes were heated to 80°C for 6 mins, cooled, added to 50 µl of 0.15% m-hydroxybiphenyl in 0.125M sodium hydroxide, and vortex agitated; the absorbance at 520 nm was then measured every 2 mins for 20 mins. The maximum absorbance was used to determine the galacturonic content based on the standard curve, which was prepared using 7 concentrations (5, 10, 20, 40, 60, 80 and 100 µg/mL) of galacturonic acid standard. The straight-line equation obtained for the standard curve was $y = 0.0112x - 0.0147$ with an R^2 value of 0.9902.

2.8.3. Degree of methylation (DM) estimation

The degree of methylation of jujube pectins from the five ripening stages was determined using a modified method based on **(Huisman, Oosterveld, & Schols, 2004)**. The pectin DM is expressed as the percentage of the total number of galacturonic acid residues esterified with a methoxyl group. SPME/CG by standard addition was used to quantify methanol released

from pectic material by saponification. Five milligrams of WSP was weighed into a headspace vial (in quadruplicate) and 1 ml of 2N NaOH was added. 1 ml of deionized water was added to the samples (duplicate), and 1 ml of methanol to the spikes (duplicate). The vials were sealed and kept at 4°C for 1 h, and then 20 mins at room temperature, and subsequently analyzed. The vials were heated to 85°C for 15 mins in a the head-space sampler, then an SPME fiber PDMS/DVB (85 µm stableflex, Chromoptique, Courtaboeuf, France) was exposed to the headspace vials while the extract was continuously stirred for 15 mins. Methanol was desorbed by inserting the SPME fiber into a GC injector (injector temperature 250°C) for 30 s in splitless mode connected with DB-WAX column (30 m, 0.25 mm ID, 0.25 µm film thickness) for 60 mins. The integration was achieved using MSD ChemStation software. The degree of methylation was estimated using Equation 1 below:

$$DM = \frac{m_{Methanol}}{MM_{Methanol}} \times \frac{MM_{Uronic\ acid}}{m_{Uronic\ acid}} \times 100$$

(Equation 1)

Where: m= mass (g), $MM_{Methanol}$ = 32g/mol, $MM_{Uronic\ acid}$ = 176 g/mol

2.9. Jujube cake processing

The processing of jujube cake comprised three individual steps: drying, grinding and cooking **(Fig.1)**. The drying was optimized with a horizontal air outlet dryer (UTA, Marmande, France) with three parameters: temperature, time and fruit configuration (whole/sliced/grinded). The impact of the flour grading on the consistency of the cake was also evaluated. The cooking parameters (time, quantity of flour and type of mold) were optimized with an Emeraude 3 steam oven (Thirode, Mitri-mory, France).

Sensory evaluation of the cake samples was carried out by 5 semi-trained panelists from CIRAD Montpellier.

3. Statistical analysis

The data were subjected to Analysis of Variance (ANOVA) using Statistica software (Statsoft, version 7). The means were separated from each other by Duncan's Multiple Range test ($p < 0.05$). Analyses were performed on three biological replicates.

4. Results

4.1. Characteristics of polysaccharide extract from jujube

WSPs from jujube fruits were obtained by precipitation with alcohol from the aqueous extract of the alcohol-insoluble material (AIM). The AIM increased slowly until the 4th ripening stage (38% to 47% DW), before a decrease at the end of the ripening (5th stage: 39.16% DW). The resulting WSPs exhibited a constantly high value (≈6%) during ripening. Previous studies by **Kannan and Susheela Thirumaran (2003)** pointed to very low pectin content in unripe and ripe *Z. mauritiana* (0.39% and 0.18% respectively). However, an increase was observed during ripening in unripe (≈0.7% DW) and ripe (≈3%DW) fruits of the *Z. jujuba* Huanghua cultivar, whereas a constant value (≈3% DW) was obtained for the Zhanhua cultivar **(H. Wang et al., 2012)**. The content of uronic acid extracted from the jujube WSP increased slowly until the 4th ripening stage (40.58 to 46.81 %), and then reached 57.25% at the 5th stage. For the DM, a significant decrease was observed from the 4th ripening stage (36.07%) (**Tab.1**).

4.2. The jujube cake processing

4.2.1. Impact of temperature and fruit configuration on quality of drying

The temperature and fruit configuration have a high impact on quality of drying, as shown in **table 2**. Whole and scalped fruits were dried only on the skin, and were finally burned, whereas the pulp was cooked. However fruits sliced before drying exhibited acceptable drying. Conversely, the ground fruits formed a mesh during drying, and became very hard.

4.2.2. Impact of cooking time

The cooking time was optimized in relation with the cake consistency. The consistency changed and became more compact as time increased, exhibiting loss of the flavor and aroma characteristics. Firmness was determined 2 h and 24 h after baking, to evaluate the possible modification of the consistency due to water absorption.

The cake firmness increased with cooking time, both 2 h and 24 h after the end of cooking. However an insignificant increase was observed after 7 mins and 10 mins of cooking, regardless of the measurement (2 h or 24 h). In addition, no significant difference between 2h and 24h was observed after 7 mins of cooking (**Fig.2**).

4.2.3. Impact of flour grading on cake consistency

The flour grading was shown to have an impact on the cake consistency. The fine and coarse grading gave a worse consistency irrespective of the cooking time. However, the intermediate

grading (465 µm) was chosen for baking jujube cakes, because of the soft and melting texture (**Tab.4**).

4.3. Effect of process on nutritional quality of jujube cake

Flour from the ripening stage 3 was designated "3 flour", and flour from stage 5 "5 flour". Likewise, fruits from stage 3 were designated "3 fruits" and fruits from stage 5 as "5 fruits".

4.3.1. Impact of ripening stages on nutritional quality of jujube cake

In order to evaluate the impact of ripening stage on the nutritional quality of jujube cake, 3 fruits and 5 fruits were used in processing to make jujube cake, as shown in figure 6. Chemical analyses were carried on fruits, flours and cakes (**Table 4**). 3 fruits exhibited high ascorbic acid content (133.35 mg/ 100 g DW), with a large decrease in 5 fruits (95%). This last ripening stage 5 fruit also showed a lower total phenolics content (61%) and antioxidant capacity (87%) than stage 3 fruit. Previous works have highlighted the decrease in nutritional quality during ripening **(Zozio, Servent, Cazal, et al., 2014; Zozio, Servent, Hubert, et al., 2014)**

4.3.2. Impact of drying process and cooking on nutritional quality of cake

Unexpectedly, the drying process did not affect the total phenolics content or the antioxidant capacity, irrespective of the ripening stage. Conversely, ascorbic content was reduced dramatically: 80% for 3 flour and 76% for 5 flour **(Table 4)**. A previous study on *Z.jujuba* showed a decrease of vitamin C (65%), phenolic content (32%) and antioxidant activity (40%) during drying at 65°C **(Abozeid, Helmy, Nadir, & Abou-Arab, 2011).** Surprisingly, the cakes from 3 flour (3 cakes) and cakes from 5 flour (5 cakes) exhibited a 30% increase of total phenolics content, and 60% for the antioxidant capacities from the flours. A similar antioxidant improvement during steam cooking was found in jujube cake **(Dairou, Biyanzi, Pallet, & Ndjouenkeu, 2014)**. This enhancement may be due to naturally occurring compounds or formation of new compounds, such as Maillard reaction products with antioxidant activity **(Nicoli, Anese, & Parpinel, 1999)**. Furthermore, cooking was found to increase total phenolics in green beans, pepper and broccoli **(Turkmen, Sari, & Velioglu, 2005)**. It was reported that heat treatment increased the level of free flavonols in tomatoes by releasing conjugated quercetin as rutin **(Stewart et al., 2000)**. A study on phenolic acids of citrus peel showed that the free compounds increased after heat treatment; as opposed to ester, glycoside and ester-bound compounds which declined, as did flavanone glycosides **(Xu, Ye, Chen, & Liu, 2007)**. Phenolic compounds are present in different bound states in plants

(Nwaichi & Anyanwu, 2013; Yao & Ren, 2011) and may be cleaved and rearranged into more soluble forms by thermal processing, which leads to an increase in antioxidant activity **(Dini, Tenore, & Dini, 2013)**.

In a previous study, an increase of p-coumaric acid (1.8 to 4.3 mg/kg DW) and ferulic acid (48%) were found after sun-drying of *Z.jujuba* **(Gao, Wu, Wang, Xu, & Du, 2012)** and after microwave, vacuum and roasting treatment for *p*-coumaric acid **(Ravichandran, Ahmed, Knorr, & Smetanska, 2012)**. Likewise, ascorbic acid content showed a big increase from 3 and 5 flours to 3 cakes (48%) and 5 cakes (73%).

5. Discussion

Jujube cake preparation was optimized in a steam oven, with various temperatures and cooking times, different flour grading and tins, in order to achieve the flavor, aroma and consistency characteristics ascribed to the traditional jujube cake found in Africa. The optimized drying parameters were 45°C/24 h/sliced fruits, and the cooking parameters were 3 g of jujube flour cooked for 10 mins with an intermediate grading of flour (465 µm) **(Fig.1)**. After 7 mins of cooking, jujube flour was compacted, but the cake was finished after 10 mins, when the specific jujube flavor was released. This property of compaction may be attributed to the gelling ability of pectin polysaccharides **(Evageliou, Richardson, & Morris, 2000; Wang, et al., 2012)**. Indeed, our results showed a high WSP content during ripening (6%), with a high content of galacturonic acid (50%). Furthermore, with regard to its DM (less than 50%), jujube polysaccharides were classified as “low methylated" polysaccharide. Therefore, the gel was created with bivalent ions such as calcium. *Z.mauritiana* lamk cv Gola from Senegal revealed a high calcium content (488 mg/100 g DW) **(Danthu et al., 2002a)**.

Traditionally in Cameroon, jujube cake was baked using the last ripening stage 5. However, the nutritional quality was very low in fresh fruit picked at this stage, as described in previous work **(Zozio et al., 2013)**. 3 fruits exhibited a higher total phenolic content, ascorbic acid content and antioxidant capacities than 5 fruits. In particular, 3 fruits have a similar WSP content **(Tab.1)**. Then jujube cake was prepared with ripening stage 3 and 5 fruits, in order to evaluate their impact on nutritional quality of the resulting cakes. Whereas the drying process decreased the ascorbic acid in 3 and 5 flours, it did not affect the total phenolic content or antioxidant capacity. Surprisingly, cooking had a big impact on the flour, producing cakes with higher nutritional quality. However, the study by Kavitha showed that the blanching process on jujube fruit increase the total flavonoid content and phenolic content, and

Thiobarbituric Acid Reactive Substance (TBARS) activity; whereas it reduces the scavenging radical activity, reducing power activity and total phenolic content (**Kavitha & Aparna, 2014**). During baking, the change in rheological properties of polysaccharides may involve the synergy of other phytochemicals **(Nitta & Nishinari, 2005)**, leading to an increase of the antioxidant activity. Moreover, it should be noted that pectins with high degree of esterification (49%) from *Z. jujuba* have greater immunological activity **(J. Li, Liu, Fan, Ai, & Shan, 2011)**.

The increase of ascorbic acid in cake should be explained by the reduction of dehydroascorbate formed during the drying process, leading to ascorbate during cooking **(Barycki et al., 2007)**.

A previous study on jujube cake showed high quality attributes of some jujube-based products such as beverages, compotes, jam, dried candy, syrup and cakes **(Helmy, Abozeid, & Nadir, 2012)**. Furthermore, cakes with 20% dried jujube exhibited better nutritional qualities than conventional cakes **(Abozeid, Helmy, Nadir, & Abou-Arab, 2011)**. This study revealed the real nutritional advantage of processing a cake from a defined ripening stage of jujube fruits.

6. Conclusion

Overall, our results gave a jujube cake preparation method with high nutritional qualities and flavors. The elevated nutritional value of jujube from ripening stage 3 and 4 can be preserved and enhanced by cooking. Thus, the limited post-harvest life of jujube fruits can easily be overcome by processing. This study revealed the real culinary advantage of cooking to produce high added-value products from jujube. Furthermore, the high biological activities of jujube polysaccharides bring consumers more benefit from this fruit.

ACKNOWLEDGEMENT

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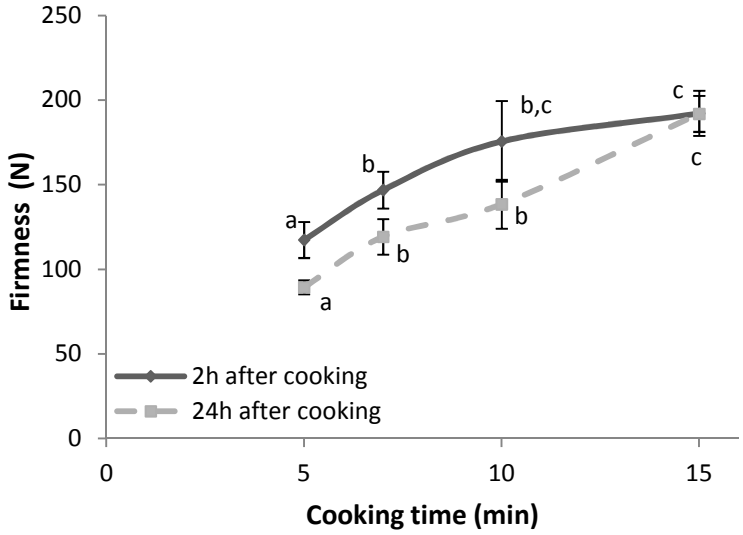

Figure 2: Evolution of firmness of jujube cakes as a function of cooking time (5, 7, 10 and 15 mins) 2 h and 24 h after the end of cooking

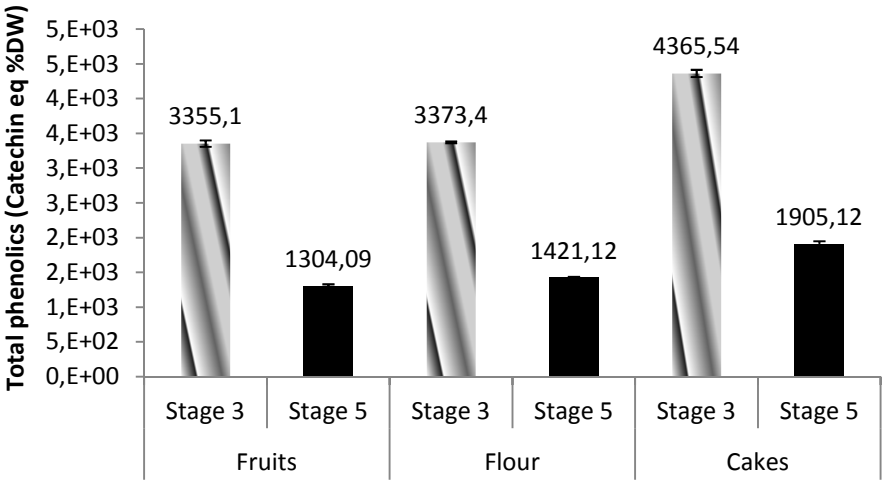

Figure 3: Effect of the drying and cooking on total phenolics are expressed as % DW equivalent catechin on jujube fruits from ripening stages 3 and 5

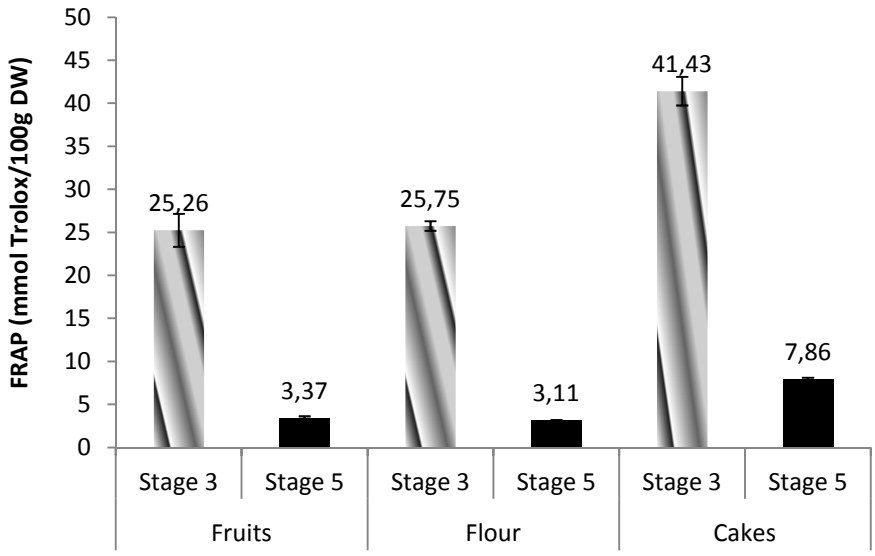

Figure 4: Effect of drying and cooking on the antioxidant capacity measured by FRAP assays on fruits from ripening stages 3 and 5

Table 1: Characteristics of polysaccharides extracted from jujube cultivar P3 during ripening

Ripening stage	AIM (%DW)	WSP (% DW)	GuAc (% WSP DW)	DM (%)
1	38.35[a] (4.69)	6.06[a] (1.08)	40.584[a] (2.46)	46.52[a] (3.75)
2	42.87[a] (6.99)	5.65[a] (1.21)	40.994[a] (2.32)	47.31[a] (2.61)
3	45.52[a,b] (7.13)	5.44[a] (1.40)	44.45[a,b] (2.42)	45.77[a] (4.73)
4	47.39[b] (5.63)	5.14[a] (1.12)	46.81[b] (2.41)	36.07[b] (3.93)
5	39.16[c] (5.99)	4.67[a] (0.83)	57.25[c] (2.68)	37.61[b] (2.53)

AIM: Alcohol Insoluble Material
WSP: Water Soluble Polysaccharide
GuAc: Galacturonic acid
DM: Degree of Methylation

Table 2: Impact of fruit configuration and temperature on quality of drying. The quality of drying was defined by the number of (+) symbols: slightly dry (+), moderately dry (++) and correctly dry (+++).

Step of experiment	Configuration of fruits	Temperature applied °C	Quality of drying	Observations
1	Whole	60	+	Burnt skin, Pulp not dried
2	Whole	45	+	Pulp not dried
3	Scalped	50	+	Skin burned
4	Sliced	35	+	Correctly dried
5	Ground	35	++	Pulp not dried
6	Sliced	45	+++	Formation of a hard mesh

Table 3: Impact of the jujube flour grading on cake consistency

Grading nomenclature	Grading (µm)	Consistency of cake
Fine	75[a] (1.70)	Pasty and sticky
Intermediate	465[b] (24.70)	Soft and melting
Coarse	812[c] (61.78)	Grainy

Table 4: Physico-chemical characteristics of jujube fruits, flours after drying and cakes after cooking from ripening stages 3 and 5

Characteristics	Fruits		Flours		Cakes	
	Stage 3	Stage 5	Stage 3	Stage 5	Stage 3	Stage 5
Pulp (%)	88.89 *(0.28)*	84.25 *(1.48)*	-	-	-	-
pH	3.33 *(0.05)*	3.52 *(0.03)*	3.43 *(0.01)*	3.43 *(0.02)*	3.43 *(0.04)*	3.43 *(0.06)*
TSS (% DW)	60.2 *(3.67)*	81.27 *(0.40)*	82.63 *(1.19)*	74.47 *(1.2)*	80.12 *(2.32)*	75.21 (1.21)
Titratable acidity (%)	1.23 *(0.01)*	1.41 *(0.049)*	7.29 *(0.05)*	7.38 *(0.02)*	6.54 *(0.06)*	6.66 *(0.04)*
TSS/Titratable acid	9.75	10.71	11.11	9.65	12.25	10.60
Total sugar (%)	-	-	24.00 *(0.67)*	24.42 *(0.72)*	23.65 *(0.86)*	23.84 *(0.97)*
Dry matter (%)	19.92 *(0.09)*	18.58 *(0.38)*	98.05 *(0.02)*	95.63 *(0.05)*	96.77 *(0.75)*	93.89 *(0.37)*
Ascorbic acid (mg/100g DW)	267.78 *(7.54)*	5.64 *(0.32)*	68.23 *(4.43)*	1.37 *(0.04)*	82.21 *(6.23)*	6.60 *(0.09)*

References

Abozeid, W. M., Helmy, I. M. F., Nadir, A., & Abou-Arab, E. A. (2011). Production and Development of New Products from Local and Chinese Ber Fruits. *Australian Journal of Basic and Applied Sciences, 5*(6), 652-659.

Barycki, J. J., Asard, H., Stone, J. M., Wilson, M. A., Banerjee, R., & Becker, D. F. (2007). Antioxidant Molecules and Redox Cofactors *Redox Biochemistry* (pp. 11-47): John Wiley & Sons, Inc.

Chang, S. C., Hsu, B. Y., & Chen, B. H. (2010). Structural characterization of polysaccharides from Zizyphus jujuba and evaluation of antioxidant activity. *International Journal of Biological Macromolecules, 47*(4), 445-453.

Dairou, S., Biyanzi, P., Pallet, D., & Ndjouenkeu, R. (2014). Traditional production, processing and quality attributes of *Ziziphus mauritiana* in Savannah region of Cameroon *Journal of scientific research and reports, 3*(5), 686-699.

Danthu, P., Solovievc, P., Tottéc, A., Tinee, E., Ayessouf, N., Gayeb, A., . . . Falle, M. (2002a). Caractères physico-chimiques et organoleptiques comparés de jujubes sauvages et des fruits de la variété Gola introduite au Sénégal. *Fruits, 57*, 173-182.

Dini, I., Tenore, G. C., & Dini, A. (2013). Effect of industrial and domestic processing on antioxidant properties of pumpkin pulp. *LWT - Food Science and Technology, 53*(1), 382-385.

Evageliou, V., Richardson, R. K., & Morris, E. R. (2000). Effect of pH, sugar type and thermal annealing on high-methoxy pectin gels. *Carbohydrate Polymers, 42*(3), 245-259.

Fraeye, I., Duvetter, T., Doungla, E., Van Loey, A., & Hendrickx, M. (2010). Fine-tuning the properties of pectin–calcium gels by control of pectin fine structure, gel composition and environmental conditions. *Trends in Food Science & Technology, 21*(5), 219-228.

Gao, Q.-H., Wu, C.-S., Wang, M., Xu, B.-N., & Du, L.-J. (2012). Effect of Drying of Jujubes (Ziziphus jujuba Mill.) on the Contents of Sugars, Organic Acids, Î±-Tocopherol, Î²-Carotene, and Phenolic Compounds. [doi: 10.1021/jf3026524]. *Journal of Agricultural and Food Chemistry, 60*(38), 9642-9648.

García-González, C. A., Alnaief, M., & Smirnova, I. (2011). Polysaccharide-based aerogels—Promising biodegradable carriers for drug delivery systems. *Carbohydrate Polymers, 86*(4), 1425-1438.

Helmy, I. M. F., Abozeid, W. M., & Nadir, A. (2012). Nutritional Evaluation of Some Products from Ber Fruits. *Nature and science, 10*(8), 37-46.

Huisman, M. M. H., Oosterveld, A., & Schols, H. A. (2004). Fast determination of the degree of methyl esterification of pectins by head-space GC. *Food Hydrocolloids, 18*, 665-668.

Kannan, S., & Susheela Thirumaran, A. (2003). Physico-chemical changes during ripening of ber (*Zizyphus mautiana* Lam.) fruits on the plant and in storage. *J.Food Sci.Technol., 40*(5), 550-551.

Kavitha, C., & Aparna, K. (2014). Effect of Processing on Antioxidant Properties of Ber (*Zizyphus mauritiana*) Fruit *International Journal of Science and Research (IJSR), 3*(7), 2019-2025.

Li, J.-w., Ding, S.-d., & Ding, X.-l. (2007). Optimization of the ultrasonically assisted extraction of polysaccharides from Zizyphus jujuba cv. jinsixiaozao. *Journal of Food Engineering, 80*(1), 176-183.

Li, J.-W., Fan, L.-P., Ding, S.-D., & Ding, X.-L. (2007). Nutritional composition of five cultivars of chinese jujube. [doi: DOI: 10.1016/j.foodchem.2006.08.016]. *Food Chemistry, 103*(2), 454-460.

Li, J., Fan, L., & Ding, S. (2011). Isolation, purification and structure of a new water-soluble polysaccharide from Zizyphus jujuba cv. Jinsixiaozao. *Carbohydrate Polymers, 83*(2), 477-482.

Li, J., Liu, Y., Fan, L., Ai, L., & Shan, L. (2011). Antioxidant activities of polysaccharides from the fruiting bodies of Zizyphus Jujuba cv. Jinsixiaozao. *Carbohydrate Polymers, 84*(1), 390-394.

Li, J., Shan, L., Liu, Y., Fan, L., & Ai, L. (2011). Screening of a functional polysaccharide from Zizyphus Jujuba cv. Jinsixiaozao and its property. *International Journal of Biological Macromolecules, 49*(3), 255-259.

Nicoli, M. C., Anese, M., & Parpinel, M. (1999). Influence of processing on the antioxidant properties of fruit and vegetables. *Trends in Food Science & Technology, 10*(3), 94-100.

Nitta, Y., & Nishinari, K. (2005). Gelation and gel properties of polysaccharides gellan gum and tamarind xyloglucan. *J. Biol. Macromol., 5*, 47-52.

Nwaichi, E. O., & Anyanwu, P. (2013). Effect of heat treatment on the antioxidant properties of Tetrapleura tetraptera, Xylopia aethiopica and Piper guineense. *Journal of Medical Research and Development, 2*(3), 59-63.

Pareek, S., Kitinoja, L., Kaushik, R. A., & Paliwal, R. (2009). Postharvest physiology and storage of ber. *Stewart Postharvest Review, 5*(5).

Pawlowska, A. M., Camangi, F., Bader, A., & Braca, A. (2009). Flavonoids of *Zizyphus jujuba L.* and *Zizyphus spina-christi (L.)* Willd (Rhamnaceae) fruits. [doi: DOI: 10.1016/j.foodchem.2008.06.053]. *Food Chemistry, 112*(4), 858-862.

Ravichandran, K., Ahmed, A. R., Knorr, D., & Smetanska, I. (2012). The effect of different processing methods on phenolic acid content and antioxidant activity of red beet. *Food Research International, 48*(1), 16-20.

Shobha, D., & Bharati, P. (2007). Value addtion to Ber (*Zyziphus mauritiana Lamk.*) trought preparation of pickle. *Kanataka J.Agric.Sci., 20*(2), 353-355.

Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. In P. Lester (Ed.), *Methods in Enzymology* (Vol. Volume 299, pp. 152-178): Academic Press.

Stewart, A. J., Bozonnet, S., Mullen, W., Jenkins, G. I., Lean, M. E. J., & Crozier, A. (2000). Occurrence of Flavonols in Tomatoes and Tomato-Based Products. [doi: 10.1021/jf000070p]. *Journal of Agricultural and Food Chemistry, 48*(7), 2663-2669.

Thanatcha, R., & Pranee, A. (2011). Extraction and characterization of mucilage in *Ziziphus mauritiana* Lam. *International Food Research Journal 18*, 201-212.

Turkmen, N., Sari, F., & Velioglu, Y. S. (2005). The effect of cooking methods on total phenolics and antioxidant activity of selected green vegetables. *Food Chemistry, 93*(4), 713-718.

Wang, D., Zhao, Y., Jiao, Y., Yu, L., Yang, S., & Yang, X. (2012). Antioxidative and hepatoprotective effects of the polysaccharides from Zizyphus jujube cv. Shaanbeitanzao. *Carbohydrate Polymers, 88*(4), 1453-1459.

Wang, H., Chen, F., Yang, H., Chen, Y., Zhang, L., & An, H. (2012). Effects of ripening stage and cultivar on physicochemical properties and pectin nanostructures of jujubes. *Carbohydrate Polymers, 89*(4), 1180-1188.

Xu, G., Ye, X., Chen, J., & Liu, D. (2007). Effect of Heat Treatment on the Phenolic Compounds and Antioxidant Capacity of Citrus Peel Extract. [doi: 10.1021/jf062517l]. *Journal of Agricultural and Food Chemistry, 55*(2), 330-335.

Yao, Y., & Ren, G. (2011). Effect of thermal treatment on phenolic composition and antioxidant activities of two celery cultivars. *LWT - Food Science and Technology, 44*(1), 181-185.

Zhang, H., Jiang, L., Ye, S., Ye, Y., & Ren, F. (2010). Systematic evaluation of antioxidant capacities of the ethanolic extract of different tissues of jujube (*Ziziphus jujuba Mill.*) from China. *Food and Chemical Toxicology, 48*(6), 1461-1465. doi: 10.1016/j.fct.2010.03.011

Zozio, S., Servent, A., Cazal, G., Mbéguié-A-Mbéguié, D., Ravion, S., Pallet, D., & Hiol, A. (2014). Changes in antioxidant activity during the ripening of Jujube (Ziziphus mauritiana Lamk). *Food Chemistry, 150*, 448-456.

Zozio, S., Servent, A., Hubert, O., Hiol, A., Pallet, D., & Mbéguié-A-Mbéguié, D. (2014). Physicochemical and biochemical characterization of jujube (Ziziphus mauritiana Lamk) fruits ripening from two accessions grown in Guadeloupe *Scientia Horticulturae* 175: 290–297