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Comparative Study between Fermented Lactic Acid Bacteria Solution and Brine Solution on Reduction of Acrylamide formed during Production of Fried Potato

Rehab A Mostafa, Maha IK Ali* and Maha A Mahmoud

Abstract

Recently, acrylamide has become one of the most important and most serious global problems, so it has been classified as a potential carcinogen and known to be a neurotoxic, occurs in heated starchy foods such as potato products (French fries and potato crisps). The present research addressed this issue by determining levels of the acrylamide precursors (asparagine and reducing sugars) and levels of the acrylamide in French fries made from two cultivars of potatoes (Cara and Banba) after immersion in fermented lactic acid bacteria solution (60 and 90 min) or brine solution (5 days) comparing to the control samples after frying process. The results indicated that the brine solution treatment appeared better sensorial properties with the panelists than the other treatments in both varieties, whereas Cara 90 and Banba 90 appeared better color and texture than the other samples using a Hunter colorimeter and a Brookfield texture analyzer. Also Cara 90 and Banba 90 treatments showed the lowest values of asparagine (2.50 and 9.08 mg/100 g), glucose (34.00 and 34.12 mg/100 g), sucrose (60.08 and 21.09 mg/100 g) and intermediate values of fructose (6.47 and 4.71 mg/100 g). With keeping in mind that asparagine and glucose values in the Cara cultivar were lower than the Banba cultivar and the opposite was found in fructose and sucrose values. And finally it was noticed that the acrylamide formation was the lowest in Cara 90 and Banba 90 (104 and 152 μg/kg) treatments, whereas the highest values of the acrylamide were for the control samples of Banba and Cara (823 and 692 μg/kg) and it was found that the Cara variety was better than in most of determined parameters than the Banba variety.

Keywords

Acrylamide; Acrylamide precursors; Asparagine; Lactic acid bacteria

***Corresponding author:** Maha IK Ali, Department of special food and nutrition, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt, E-mail: mahaik82@yahoo.com

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Introduction

Acrylamide is a chemical compound and formed at high food processing temperatures specially food containing carbohydrates or starchy substances, such as fries, fried potatoes, chips, toast and roasted coffee beans. Formation of acrylamide occurs through the reaction of reducing sugars such as fructose or glucose with the amino acid asparagine at high temperatures and low moisture content. The most likely route to acrylamide formation in French fries is acrylamide precursors such as asparagine and reducing sugars, which affect the concentration of precursors such as variety [1,2].

The effects of long term and low level exposure in humans based are predicted by animal studies data involving short-term high-level exposures. Uncertainties in extrapolation can be, in part, based on potentially different mechanisms associated with different exposure scenarios. Crofton et al., [3] studied that the adequacy of short-term exposures to acrylamide for evaluating neurotoxicity produced by long-term exposures. The neurotoxic effects of acrylamide (ip) were assessed in rats after acute (0–150 mg/kg), 10-day (0–30 mg/kg), 30-day (0–20 mg/kg), and 90-day (0–10 mg/kg) exposures. The neurotoxicity of acrylamide was less than that predicted by a strict dose *x* time relationship. Behavioral endpoints showed both qualitative and quantitative changes as a function of dose rate. Recovery of behavioral function. Also, they found that was independent of the duration of dosing. Because duration of dosing had no impact on the kinetics of acrylamide, these data indicate that the toxicity of acrylamide is not due to an accumulation of acrylamide in the target tissue. The less than strict cumulative toxicity of acrylamide may result from an interaction between administered dose, tissue damage, and repair processes. Therefore excellent raw material is a prerequisite for a lower acrylamide formation during frying and roasting. Therefore adapted varieties may substantially contribute to minimize consumer's exposition to acrylamide [1].

The potato varieties identification based on morphological of plants and tubers are not precise because they are highly influenced by environmental conditions. For these purposes it is therefore reasonable to search for stable traits of tubers. There were two varieties of potatoes, Cara and Banba varieties, Cara variety is late main crop variety with pale yellow flesh that is floury on cooking. The tubers are round to oval in shape and the peel is white with shallow red eyes and it is suitable for boiling and salad while Banba variety is firm when cooked, high yielding variety, round and smooth skinned tubers with pale yellow flesh and pale skin and it is suitable for baking, boiling, chipping and roast [4]. Sharara and Ghoneim [5] studied Cara varieties of potatoes and they found that Cara had the highest lightness. French fries prepared from this variety were accepted by panelists for all organoleptic properties. The results indicated that drying under vacuum at 60°C for 0.5 and 1 hour, blanching at 95°C for 4 min, after soaking in NaCl 3% for 50 min, and increasing the thickness of potato sticks could significantly decrease oil uptake of potato sticks during French fries processing. The changes that occur on physical and chemical properties of tubers of potato Banba cultivar at the end of storage period, were the tuber weight decrease, chips efficiency and the oil ratio of chips increased and there was no any change on protein content [6].

Lactic acid Bacteria (LAB) consume simple sugar during its metabolism and convert the simple sugars (glucose and fructose) to lactic acid which causes lowering in acidity number pH and inhibits the Millard reactions that's occurs between the amino group of the free amino acid asparagine and the carbonyl group of reducing sugars during frying [7,8].

Pickling is a conventional method; the vegetable is placed in a combination of salt and water. The potatoes are covered in brine for a prescribed amount of time. In this submerged, airless state (below the brine line), the potatoes ferment. Fermentation is the process by which the natural bacteria in the foods convert the sugars into lactic acid. Lactic acid is a natural preservative. Depending on its strength, microorganisms will not grow in lactic acid because of its low pH (high acidity), therefore pickling of potatoes is used to reduce the acrylamide formation component during the frying process, where it was pickled with brine solution [9].

The aim of this study is to illustrate the potential of using lactic acid bacteria and pickling to reduce the formation of carcinogenic acrylamide component in the French fries of two varieties of potatoes (Cara and Banba) and their effects on some organoleptic properties such as colour and texture, in addition to study the relation between acrylamide formation and its precursors in these treatments.

Materials and Methods

Materials

Cara and Banba potatoes varieties were obtained from Abeis farmer of Agriculture Faculty, Alexandria University. Sea salt was obtained from local market.

Methods

Batch experiment and incubation of potato samples: Blancher water (2 L) was incubated with *Lactobacillus bulgaricus* strain DSM20080 and incubated at ambient temperature (approximately 30°C) for 20 hour. The culture was harvested by centrifugation in K centrifuge × 1000 rpm Harmonis Series. The volume of the fermenting bath was approximately one liter. Potatoes (1 kg) of Cara and Banba varieties were washed, peeled and cut wave formed at 9 cm, 1cm and 1cm size per stick. Potato sticks were taken and exposed the fermenting bath for 0 (control), 60, 90 min according to Baardseth et al., [10] or soaked at 4% sterile brine solution under anaerobic condition for five days before the pre-frying according to Panda et al., [11]. After exposure, (Pan frying was done with constant stirring, time and temperature were 2.5 min at 170°C in sunflower oil) and kept after cooling prior to a freezing storage (-20 °C) for 2 days. The samples were fried 2nd deep-frying for 3 min and photographed. The frying samples analyzed for asparagine, sugars and acrylamide.

Sensory analysis: The four samples formulated for both cultivars (Cara and Banba) in the present study were served to 10 trained panelists consisting of students of the University of Alexandria. The panelists were asked to judge the samples on 9-point Hedonic scale. The samples and the control were evaluated corresponding color, taste, odor, texture and overall acceptability [12].

Color analysis: Color of fried potatoes was measured within 30 minutes of frying using Hunter Lab Ultra the fried potato samples using a Hunter Lab Scan Visible (USA) colorimeter and value for L^* (Lightness), a^* (redness) and b^* (yellowness) were obtained as described by Brunton et al. [13].

Texture analysis: Texture profile analysis of fried potatoes hardness, recoverable deformation, adhesive force, adhesiveness and resilience were measured by Brookfield CTV 1.2 texture analyzer with TA-RT-KI fixture and 10,000 g load cell. The analyzer was set to perform single cycle measurements. Compression tests were performed with samples placed 4.0 mm from the needle probe TA38 moving at 10 mm/s, 0 seconds holding time, trigger load 5 g, test and return speed 10mm/s and data rate 10 points/s [14].

Asparagine analysis: 5 grams of potato samples were mixed with 50 ml water, it were centrifuged at (10,000 rpm 10 min, 4°C), Asparagine was converted to its 9-fluorenylmethylchloroformiate (FMOC) by mixing the extract with the derivatization agent for 2 min at pH 10.0, The cleaned extract was derivatized with nhexane and 20 µl of final sample was injected into HPLC system, HPLC separation was performed by gradient elution on a ODS column using 0.01 mol/L acetonitrile (A) and 50 mM aqueous acetate buffer (B) at a flow rate of 1.0 mL/min at 25°C. Acetonitrile ratio was increased from 0% to 25% within 10 min, and to 100% within 5 min. Each sample was analyzed in duplicate aqueous acetate buffer (B) at a flow rate of 1.0 mL/min at 25°C. Acetonitrile ratio was increased from 0% to 25% within 10 min, and to 100% within 5 min. Each sample was analyzed in duplicate [15].

Sugars analysis: Sugars standards all with a purity exceeding 99.0% were purchased from Sigma-Aldrich Chemicals Co. (St Louis, MO, USA).

Sample preparation: Samples were diluted 1:10 (w/v) as method described by Chinnici et al., 2005 with deionized water and then filtered through a 0.22 µm filter membrane. An aliquot of 1.5 mL of these solutions was placed in vials for the analysis.

Sugars Sucrose, glucose, and fructose were determined by high-performance liquid chromatography (HPLC). The chromatographic system Agilent (series 1200) coupled to the refractive index detector was equipped with a quaternary pump, degasser and auto injector. The chromatographic data were acquired using the Agilent software. The samples obtained as described above were analyzed using an Aminex-carbohydrate HPX-87 column under isocratic condition with deionizes water. The flow rate was 0.5 mL/ min. The column temperature was maintained at 85 °C and the detector at 50 °C. Sample detection was performed by comparing retention tim was adapted with modifications from Varian [16]. Potato samples (1 g) of fresh potatoes in 10 mL acetonitrile/water (80:20 v/v) were stirred for 5min. The suspension was then centrifuged at 1700 × g for 10 min and the supernatant was passed through a 0.45-m Millex filter (Millipore, Bedford, Mass., U.S.A.). Aliquots (50 L) of the filtrate were injected into high-performance liquid chromatography (HPLC) using a Hewlett Packard 1100 Series chromatography system (Agilent Technologies, Inc.,Palo Alto, Calif., U.S.A.) The mobile phase was water, and the system was operated at 80°C at a flow of 0.4 mL/min. Sucrose, glucose, and fructose (Chem Service, West Chester, Pa., U.S.A.) were used as external standards [10].

Acidity number (pH): Acidity number was determined by pH meter in duplicate samples of potato juice were carefully thawed on ice and pH was measured immediately using a pH meter previously calibrated using buffers at pH of 4, 7, and 10 [17].

Acrylamide analysis: Acrylamide was analysed using solid-phase extraction before liquid chromatography/mass spectrometry as described by Young et al. [18] The homogenization step was slightly modified as 5 g homogenized sample was diluted to 100 mL with water, vigorously shaken for 30 min, and adjusted to pH 7 to 9 by

0.5 MNaOH. The mixture was filtered through glass-fiber by suction, before aliquots were applied on the preconditioned SPE columns. The final analysis is done by high-performance liquid chromatography (HPLC) using a Hewlett Packard 1100 Series chromatography system (Agilent Technologies, Inc.,Palo Alto, Calif., U.S.A).

Statistical analysis

The analysis of variance was done using SAS Statistical software for windows 7. The means were compared using Duncan's multiple range tests. Statistical significance was expressed at the $p<0.05$ level [19].

Results and Discussions

Sensory properties

Table 1 illustrated the overall acceptability property of the French fries from two varieties of potatoes (Cara and Banba) was important to predict the quality of the final product and it was located in similar zone and classified as moderately like according to 9-point Hedonic scale and the other properties ranged from slightly to moderately like. Also, among the tested treatments in each cultivar the brine treatment appeared better color, odor and texture properties than the others in both varieties. Ross [20] showed that numbers of food processors stated that the sensory methods were too costly and too time consumptive to be an efficient method of quality control. Also, Blom et al. [7] stated that the sensory properties was used as an indicator on the good quality of potato product and he found significant difference in the color between the control product and treated ones, but there were no clear difference in taste, texture or odor properties. Also, there was no unacceptable taste in fermented French fries and the unfermented samples. Lowering of pH by submerging in 1% citric acid for 1 hour before frying caused no unacceptable taste as the control, whereas submerging in 2%citric acid made it slightly sour in taste and harder in texture [21].

Values followed by the same letter in a row are not significantly different at $p \leq 0.05$.

Also Figures 1 and 2 presented the appearance of control and treated pre-fried and fried samples for both of Cara and Banba varieties, these samples showed non identical colors and texture that can't be judged by necked eye so it was necessary to use color and texture devices.

Color and texture of fried Cara and Banba potatoes

As the sensory tests are desired to check the consumer acceptability of the final product as the instrumental tests are considered to be a more ideal method of color and texture determination. Color is one of the most important sensory attribute that affect directly the consumer preference of any product. Special attention should be given to French fries products to attract the consumer attention. The color parameters of samples were evaluated using a Hunter laboratory colorimeter, where lightness (L*), redness (a^*) and yellowness (b^*) as in Table 2, color parameters showed that the highest value of lightness was found in Banba 90 and followed by Cara 90 meanwhile the Banba control accorded the lowest value of lightness followed by the Cara control treatments. Otherwise, the redness in Cara cultivar was higher than Banba cultivar and the submerged in lactic acid bacteria for 90 min. showed the lowest value in Banba followed by Cara cultivars. Finally, the yellowness value was higher in Banba 90 treatment than in Cara 90. On the other hand, analysis of texture is unique technique for checking the products physically. The texture parameters were estimated using texture analyzer by compression test, the texture

Table 1: Sensory analysis of fried Cara and Banba potato varieties submerged for 0 (control), 60 and 90 min in lactic acid bacteria or 4% brine solutions.

Samples	Sensory properties				
	Color	Taste	Odor	Texture	Overall-acceptability
Cara control	7.14^{ab} ± 1.21	7.14^{a} ± 1.34	7.00^{a} ± 1.41	6.86^{a} ± 0.90	7.14^{a} ± 1.07
Cara brine	7.85^{a} ± 1.46	7.57^{a} ± 1.39	7.86^{a} ± 1.21	7.28^{a} ± 1.38	7.28^{a} ± 1.25
Cara 60	5.71^{b} ± 2.06	6.57^{a} ± 1.81	6.86^{a} ± 2.54	6.71^{a} ± 1.60	6.57^{a} ± 1.51
Cara 90	7.14^{ab} ± 1.21	6.71^{a} ± 1.11	6.71^{a} ± 1.25	6.57^{a} ± 1.27	7.00^{a} ± 1.15
Banba control	6.14^{ab} ± 1.77	7.14^{a} ± 1.68	6.43^{a} ± 1.89	7.14^{a} ± 2.06	7.00^{a} ± 1.53
Banba brine	7.14^{ab} ± 1.34	7.00^{a} ± 1.73	7.28^{a} ± 1.89	7.00^{a} ± 1.73	6.85^{a} ± 1.46
Banba 60	6.00^{ab} ± 1.73	7.14^{a} ± 1.57	6.43^{a} ± 1.81	7.14^{a} ± 1.22	6.71^{a} ± 1.38
Banba 90	6.57^{ab} ± 1.72	7.43^{a} ± 1.51	6.86^{a} ± 1.95	6.57^{a} ± 1.81	7.43^{a} ± 1.27

Values followed by the same letter in a row are not significantly different at $p \leq 0.05$

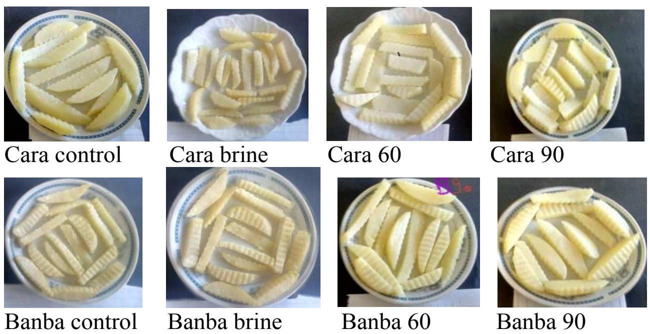


Figure 1: The appearance of pre-fried Cara and Banba potato varieties submerged in lactic acid bacteria for 0 (control), 30 and 60 min and 4% brine solutions.

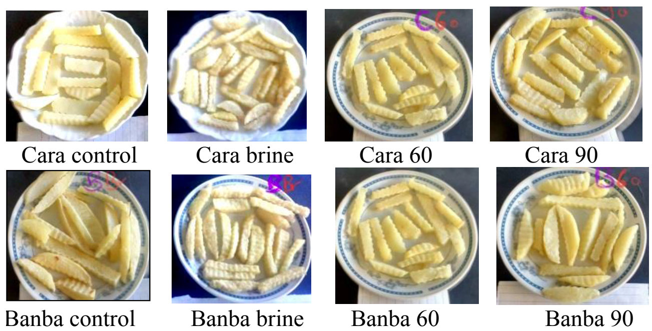


Figure 2: The appearance of fried Cara and Banba potato varieties submerged in lactic acid bacteria for 0 (control), 30 and 60 min and 4% brine solutions.

Table 2: Color and texture of fried Cara and Banba potatoes varieties submerged for 0 (control), 60 and 90 min in lactic acid bacteria or 4% brine solutions.

Samples	Color			Texture				
	L*	a*	b*	Hardness (g)	Recoverable deformation (mm)	Adhesive force (g)	Adhesiveness m J	Resilience
Cara control	61.15	7.55	24.23	659	2.69	2	0.10	0.42
Cara brine	62.78	4.49	22.67	0	0.00	- 3007	0.00	0.00
Cara 60	65.95	5.04	13.41	323	2.82	2	0.20	0.31
Cara 90	66.48	5.02	27.58	2321	2.83	1	0.00	0.37
Banba control	55.53	6.15	19.80	1012	2.91	2	0.00	0.36
Banba brine	65.28	3.56	16.75	0	0.00	- 3671	0.00	0.00
Banba 60	65.87	6.16	27.26	166	1.84	1	0.00	0.28
Banba 90	70.34	4.74	28.25	1685	2.86	2	0.20	0.42

L*=Lightness, a*= Redness and b*= Yellowness

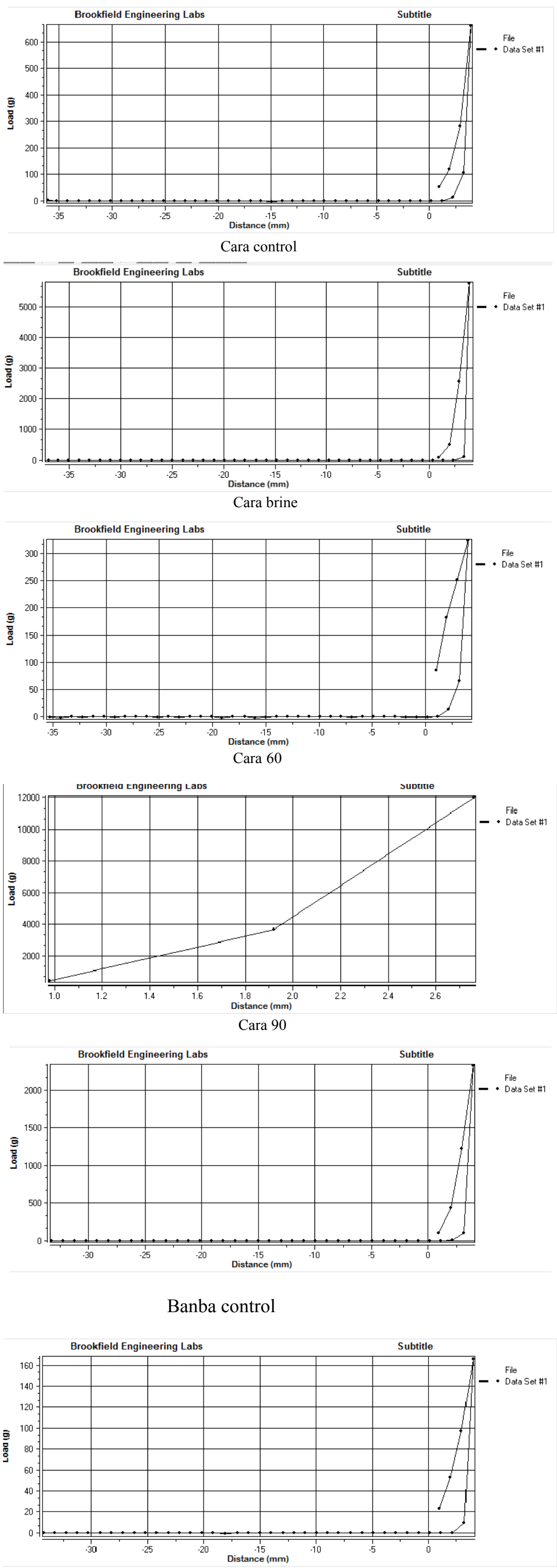
properties such hardness which express the energy required to deform the sample when biting or chewing, the highest value of hardness was in Cara 90 (2321g) followed by the Banba 90 (1685g) but the lowest value of hardness was in both Cara and Banba brine (0 g). The different treatment effects of submerged samples in Lactic acid bacteria or pickling solution on hardness scores were varied. The similar trend was noticed in the recoverable deformation in Cara 90, it was higher than the other treatments (2.83 mm) followed by Cara 60 (2.82 mm) and Cara control (2.69 mm). Different trend was found in Banba cultivar, the highest value of recoverable deformation was 2.91 mm for the control sample followed by Banba 90 was 2.86 mm and finally Banba 60 was 1.84 mm. Meanwhile, the brine treatment showed 0 mm recoverable deformation for the both varieties. The adhesive force in the brine treatment was recorded negative values (-3007 g for Cara and -3671 g for Banba, respectively) and the same parameter was ranged from 1 g to 2 g for the other treatments without stable manner. On the other side, adhesiveness is the strength of the internal bonds within the different samples which were 0.00 mJ for all samples except Cara control was 0.1 mJ and both of Cara 60 and Banba 90 were 0.2 mJ. Also, resilience is calculated as the ratio of the recoverable work done with respect to the energy required for deformation (hardness work done) where the highest value was 0.42 in Cara control and Banba 90 and the other values ranged from 0.28 to 0.37 but for the both brine treatment was zero.

The significant differences changes that occurred on physical and chemical properties of potato caused by the differences in physical and the chemical properties of Binella, Granola, Banba, Natascha, Toscana, Slaney and Marfona potato cultivars and these properties correlated with the consumer acceptability of potato. Also, the technological changes such as water losses and tissue damages and increasing in polysaccharides content resulted from thermal processes (Blanching, pre-drying and frying where fat penetrated into the external layer of strips). There were inversely effect of acrylamide content with the lightness of French fries product and the strips became darker in the L* a* b* color system and L values maybe reliable indicators of acrylamide content in potato products**.** On point of view lactic acid bacteria fermentation, there was increase lightness (increased L* values) in fried potato product due to fermentation process as well as by consumer acceptability. The color of fried products caused by the non-enzymatic Millard browning mechanism, where reaction between reducing sugars and asparagine on the surface of the product was occurred, The production of light-colored and low in acrylamide potato products became limiting requirements [22,10,13,6].

The relationships between hardness and deformation values of fried potato samples, which were fried for 2.5 min at 170˚C was illustrated in Figure 3, were different according the variety and the treatment within the same variety. The results showed that there were sharp relationships between the force which was affected on the samples and its hardness and deformation parameters, except the Cara 90 sample which showed linear relationship between the force and hardness, (12000g, 2.8 mm) with no deformation. Whereas the other samples showed different values of hardness which listed in descending order as the following Cara brine (5000g; 5 mm), Banba control(2500 g; 5 mm), Banba 90 (1600; 5 mm) Banba 60 (1000g; 5 mm), Cara control (600g; 5 mm), Cara 60 (300g; 5 mm). On the other hand the samples showed force deformation in different values the highest force deformation was in Banba brine (20g; 1 mm) and the lowest value was in Cara brine (200 g; 1 mm) whereas Banba control, Banba 60 and Banba 90 showed the same value of force deformation (100g; 1 mm) and finally the force- deformation values were (80g; 1 mm) and (50g; 1 mm) for Cara 60 and Cara control respectively. The literature mentioned that a higher hardness value indicates that material requires a higher force treatment for breaking and this can be explained as flexible. Higher hardness values and sharp vertical drop in force-deformation curve demonstrated the degree of flexible which have an opposite relation with brittle parameter [23].

Levels of Asparagine, reducing sugars acrylamide contents in fried Cara and Banba potatoes varieties

There were many precursors of formation acrylamide component in the French fries such as asparagine, glucose, fructose, sucrose and acidity number (Table 3). In this study these factors were determined and showed that the asparagine values was the highest for the both control samples (9.13 and 12.98 mg/100g) followed by brine treatment (5.84 and 11.25 mg/100 g), then the treatment for 60 min (2.71 and 9.40 mg/100 g) and finally the treatment for 90 min which was the lowest value (2.50 and 9.08 mg/100 g). The second factor which affect on acrylamide formation in the French fries samples was reduced sugar contents such as glucose and fructose. The glucose content results were matched with asparagine content in the samples which the highest content of glucose was for the control samples (73.07 and 150.34 mg/100 g) followed by brine treatments (71.63 and 127.77 mg/100 g), then Cara 60 and Banba 60 (48.71 and 69.99 mg/100 g) and finally Cara 90 and Banba 90 (34.00 and 34.12 mg/100 g). Different trend was noticed in fructose content, the highest content was for the control samples (12.36 and 9.19 mg/100 g) but the lowest content was for the brine treatments (2.81 and 2.37 mg/100 g) and the lactic acid bacteria solution treatments were intermediate values and very similar in each variety, Cara 60 and Cara 90 fructose contents were 6.59 and 6.47 mg/100 g while Banba 60 and Banba 90 fructose



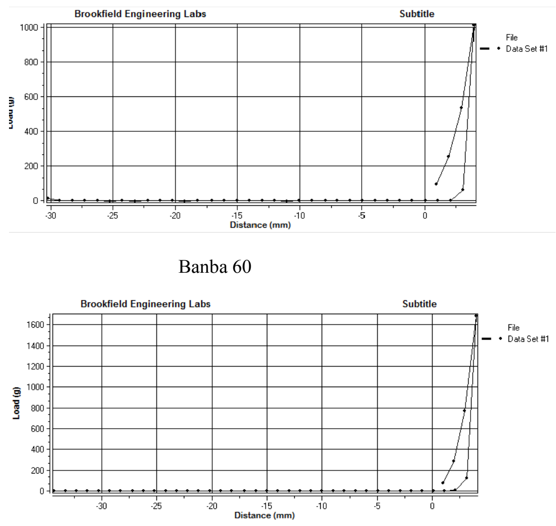
Cara control

Cara brine

Cara 60

Cara 90

Banba control



Banba brine

Banba 60

Banba 90

Figure 3: The relationship between hardness and recoverable deformation of fried Cara and Banba potatoes varieties submerged for 0 (control), 60 and 90 min in lactic acid bacteria and 4% brine solutions.

content were 4.73 and 4.71 mg/100 g, it was noted that the asparagine and glucose values in Cara cultivar were lower than Banba cultivar. On the other hand, fructose and sucrose content are other precursors in acrylamide formation, but opposite manner was noticed which the values of fructose and sucrose content were lower in Banba variety than Cara cultivars, with keeping of the same trend between the treatments (90.18 and 86.96 mg/100 g for control, 77.93 and 28.90 mg/100 g for the brine,69.69 and 21.96 mg/100 g for Cara 60 and Banba 60 and 60.08 and 21.09 mg/100 g for Cara 90 and Banba 90). The acidity number (pH) was ranged from 4.78 to 7.78, the decreasing of pH for the lactic acid bacteria solution treatments was more than the brine solution. The summation of all the above is clearly reflected in the values of acrylamide where we found that acrylamide values were the lowest in Cara 90 and Banba 90 (104 and 152 μg/kg) (84.97%, 81.53% reduction) followed by Cara 60 and Banba 60 (261 and 204 μg/kg) (62.28%, 75.21% reduction), then Cara brine and Banba brine (451 and 303 μg/kg) (34.82%, 63.18% reduction) and finally Cara control and Banba control (692 and 823 μg/kg) which showed the highest content of acrylamide.

The relationship between free asparagine (protein degradation component which brought by sprout formation), reducing sugars (glucose and fructose) and acrylamide formation in potato showed that reducing sugars being the limiting factors in acrylamide formation mechanism but free asparagine concentration has more influence in French fry rather than crisping varieties, probably because French fry varieties contain higher concentrations of sugars [24]. Blom et al. [7] showed that lactic acid fermentation produces a unique treatment to decrease the concentration of acrylamide content in French fries. Acid-soaking of samples resulted in lighter-colored French fries as compared to water-soaked samples while increasing the frying temperature resulted in darker fries. A small accumulation of reducing sugars occurred in the early stages but levels were constant over the later stages of storage. Asparagine levels were constant over the

Table 3: Asparagine, glucose, fructose, sucrose and acrylamide contents of fried Cara and Banba potatoes varieties submerged for 0 (control), 60 and 90 min in lactic acid bacteria and 4% brine solutions.

Samples	Asparagine mg/100g	Glucose mg/100g	Fructose mg/100g	Sucrose mg/100g	pH	Acrylamide μg/kg	Acrylamide reduction in %
Cara control	9.13	73.07	12.36	90.18	7.32	692	0.00
Cara brine	5.84	71.63	2.81	77.93	5.96	451	34.82
Cara 60	2.71	48.71	6.59	69.69	5.45	261	62.28
Cara 90	2.50	34.00	6.47	60.08	5.31	104	84.97
Banba control	12.98	150.34	9.19	86.96	7.78	823	0.00
Banba brine	11.25	127.77	2.37	28.90	5.25	303	63.18
Banba 60	9.40	69.99	4.73	21.96	4.95	204	75.21
Banba 90	9.08	34.12	4.71	21.09	4.78	152	81.53

storage period and no trend was observed. The acrylamide content in French fries was highly correlated with glucose (0.92), fructose (0.90) and total reducing sugar (0.92) contents but not with asparagine content (0.06). Asparagine contents were relatively constant for three varieties of potatoes over the test period and no trend in asparagine levels was noted [25]. The reduction in the formation of acrylamide by fermenting the potato rods with *L. plantarum* NC8 before deep-frying is due to reduction in the levels of reducing sugar rather than a specific reduction in the levels of available asparagine. Lactic acid fermentation also reduces formation of Maillard products, pH was reduced and sugar levels declined during fermentation [10].

Conclusions

Lactic acid fermentation is a good tool to reduce the concentration of acrylamide in French fries which causes lowering in acidity number pH and inhibits the Millard reactions and reducing sugars during frying. As well as the use of brine solution is inexpensive method to reduce formation the acrylamide component during the frying process. Brine solution treatment appeared better sensorial properties with the panelists than the other treatments in both varieties.

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Author Affiliation

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Department of Special Food and Nutrition, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt