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PRODUCTION OF TORTILLA CHIPS FROM CORN AND/OR SORGHUM. VI. QUALITY OF LEGUME ENRICHED TORTILLA CHIPS

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ABSTRACT

Defatted soybean, chickpeas and lupine flours were added to masa in 4, 8 and 12% of the corn weight. The chemical composition and amino acids content of raw materials were detected. Tortilla chips supplemented with soybean flour was characterized with the highest amounts of protein, ash, fiber, Ca, K, P, Fe, valine, histidine, glycine, lysine and phenylalnine. The mixtures containing lupine flour showed higher value of protein, fiber, Mg, Fe, Mn and higher threonine and arginine. The lowest aspartic acid and serine contents were observed in tortilla chips supplemented with chickpeas. The sulfur containing amino acids were not affected by supplementation. With respect to sensory evaluation, the obtained results indicated that no significant differences between supplemented samples by leguminous flours and control. The fortification of tortilla chips with leguminous flours proved its priority with regard to the organoleptic and physical properties of tortilla chips.

INTRODUCTION

Maize and sorghum have been used world wide for human and animal consumption, in view of its being a good source for carbohydrates. However, one of the main characteristics of these cereals is the low quality of their stored protein because of the low concentrations of lysine and tryptophan in the main stored protein fraction of the endosperm. Consequently, a diet based on maize must be supplemented with those essential amino acids. Legumes, on the other hand, serve as the main source of protein and calories in many tropical area of the world and their products are the richest sources of protein from plant food (Sathe *et al.,* 1984).

Protein content, from another side, is considered as one of the most important factors that affects tortilla ships quality. Gelatinization of starch depends on protein content as starch gelatinization is more rapid at relatively higher protein levels (Dappolonia, 1972). Addition of ingredients containing high protein into corn flour improves the dough strengthens frame work and hence automatically help in improving its processing quality. Protein content is considered one of the most important components that affect the biological value of the product, so leguminous flours have been used to fortify many products to improve their nutritional value (McWatters, 1990).

On the other hand, additives with high ash content can produce some grittiness in the baked products, while high oil content leads to some stability problems during storage (Compos and El-Dash, 1978; Lorenz *et al.*, 1979). Protein supplementation of tortillas in order to increase of level and quality of protein attracted the attention of many investigators (Serna-Saldivar *et al.,*

1988; Barron and Espinoza, 1993; Alam, 1996 and Salem *et al.,* 1999). Legumes are a good source of dietary protein (Breen *et al.*, 1977). Such proteins lack methionine but are a source substantial quantity of lysine (Fahmy *et al.*, 1981). Fortification of stable cereal-based foods with leguminous grains products has been applied in the past (Bressani, 1975; Gupta and Kapon, 1980). Theoretically, cereal-leguminous blends have higher protein contents with a quality and nutritional value similar to animal protein.

Different protein sources have been studied and recommended for use in tortilla preparation to improve its quality and nutritional values including lupins, soybean and chickpeas (Barron and Espinoza, 1993; Alam, 1996; Hussein, 1998 and Salem *et al*. 1999).

The quality of tortillas and tortilla chips in terms of acceptability, chemical composition and nutritional value is influenced by the raw materials used in tortilla preparation. So, this work was performed for improving the protein quality of corn and corn/sorghum mixture. Different proportions of lupine, chickpea, and defatted soybean flour were added to masas. The masas and legume flour were thoroughly mixed well in a blender, sheeted, baked and fried in sun flower oil. The acceptability of the products were evaluated as well as, the chemical composition and protein quality.

MATERIALS AND METHODS

I-Materials:

White corn *(Zea mays)* single cross 10 (WC10) was purchased from Corn Breeding Section, Field Crops Department, Agric. Res. Centre, Giza, Egypt. Lupine *(Lupin terms, variety Giza1)* and chickpeas (*Cicer arietinum*, Family 88) were purchased from Legumes Breeding Section, Field Crops Department, Agric. Res. Centre, Ministry of Agric., Giza, Egypt. Defatted soybean flour was obtained from Soybean Factory, Food Technology Institute, Agric. Res. Centre, Giza, Egypt.

II- Methods:

Preparation of legume flours:

Morad *et al.* (1980) technique was applied for the debittering of lupine seeds where lupine seeds were soaked in distilled water for 9 hrs. followed by boiling for an hour. and then the seeds were soaked for 48 hrs. in distilled water at room temperature. The water was periodically changed during soaking every 12hrs. The debittered lupine seeds were dried in thermostatically controlled oven at 60°C for 12 hrs., and ground using a laboratorial disc mill to pass through a 20 mesh / inch sieve .

The method of Hussein (1998) was followed for the chickpea seeds preparation where chickpea seeds were soaked in distilled water for 9 hrs followed by boiling for 30 min. The chickpea seeds were dried in a thermostatically controlled oven at 60°C for 12 hrs, then ground using a laboratorial disc mill to pass through a 20 mesh/ inch sieve.

Preparation of tortilla chips:

Tortilla chips were prepared in Food Technology and Dairy Department, National Research Centre, Dokki Cairo, Egypt as described by Serna-Saldivar *et al.* (1988). The masas were mixed with ckickpeas, lupine or defatted soybean flours at concentration of 4, 8 and 12% on dry weight basis of corn. The different kinds of masas were sheeted, cut into circular shapes and baked for 10 sec. in microwave oven into tortillas. The tortillas were then deep fried for 1min. at 190°C in sunflower oil. Tortilla chips were drained, cooled for 5min. and packed into metalized polyproplen(M/PP).

Analytical methods:

Moisture, ash, fiber, lipids and total protein were determined according to the methods recommended by the A.O.A.C. (1990). Total carbohydrates were calculated by difference. Amino acids (except trytophan) were determined according to Anderson et al. (1977). All determinations were performed in triplicates and the mean values were reported. Amino acids other than tryptophan were determined at the Central Laboratory for Food and Feed, Agric. Res. Centre, Ministry of Agric., Giza, Egypt, using high performance Amino Acid Analyzer as described by Moore *et al.* (1958).

Minerals content were determined according to the methods described by Chapman and Pratt (1978) using an Atomic Absorption Spectrophotometer (Zeiss FMD) for Fe, Zn, Mn, Cu and Mg, the flame photometer was used for K, Na and Ca, and Spectrophotometic methods for P content of the tested samples. The values were calculated as mg/100gm dry sample.

Organoleptic evaluation:

The tortilla chips were organoleptically evaluated for their color, odor, taste, texture, crispness, appearance and overall acceptability by ten trained panelists from the staff of Food Science and Technology, National Research Centre (N.R.C.), Dokki, Giza, Egypt according to Stinson and Tomassetti (1995).

Color determination:

The color of the ground tortilla chips was measured in a Hunter Lab . Color difference Meter. D25-2. A ccording to Kramer and Twigg (1970) the tortilla chips was milled to pass through a 20 mesh/inch seive. The ground tortilla chips was placed in a plastic petri dish, to the rim and leveled off with a spatula. Then the plastic petri dish was covered with a clear glass plate and placed into the colorimeter. The L (whiteness), a (redness) and b (yellowness) values were reported. Total color difference E was calculated as: $\Delta E = [(\Delta L^2) + (\Delta a^2) + (\Delta b^2)]^{½}$.

Statistical analysis:

Results of sensory evaluation of tortilla chips were statistically analyzed using analysis of variance and least significant differences (L.S.D) according to the method of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1. Chemical composition of ingredients used in tortilla chips processing:

The chemical composition of both corn and legumes flours are shown in Table (1). Results indicated that soy flour has the highest protein content (55.33%) and corn flour had the lowest content being 10.17%. Fiber contents varied among the ingredients used, and a high content was observed in the legumes flour. The presence of seed hull in lupine and chickpeas explains their relatively higher crude fiber content. The crude fibers content of corn and additives were related to the proportion of the bran layer to that of the endosperm (Mohamed *et al*., 1987).

Table (1): Chemical composition of corn and legume flours (on dry weight basis).

Component	Corn flour (%)	Lupine flour (%)	Chickpeas flour (%)	Defatted soybean flour (%)
Protein	10.17	38.34	24.72	55.33
Ether extract	4.33	8.98	6.25	1.13
Ash	2.27	3.11	1.89	5.64
Fiber	3.09	3.17	2.39	3.16
Total carbohydrate	80.14	46.40	64.75	34.74
Moisture	11.40	12.52	8.88	9.81
Minerals (mg/100g) :				
Calcium	26	132	178	274
Magnesium	116	211	35	46
Potassium	190	7	370	800
Phosphorous	240	346	213	520
Iron	4.10	6.25	10.578	8.07
Manganese	1.503	3.067	0.931	1.357
Zinc	1.70	4.37	2.58	1.21
Copper	1.53	0.235	0.28	0.304

Cereal chemists generally recognize the inadequacy of ash content as an indicator of the flour (Lorenz *et al.*, 1972). Chickpeas had the lowest in ash content while soybean had the highest amounts for the difference in thickness of outer layers. Additives with high ash content can produce some grittiness in the baked products, while those with high oil content lead to some stability problems during storage (Compos and El.Dash, 1978 and Lorenz *et al*., 1979). Lupine flour was characterized with higher oil content (8.98%) than all other legumes flour used in this study. Results obtained are confirmed with those reported by Faheid and Hegazy (1991); Barron and Espinoza (1993); Alam (1996); Hussein (1998) and Salem *et al*. (1999) .

Mineral contents of corn and legumes flours were also determined. Results indicated that legume flour were extremely rich in minerals as compared with corn flours. The highest content of K, Ca, Fe, and Zn in legume flours is expected to raise the nutritive value of corn flour used for tortilla chips making. From Table (1) it could be noticed that soy flours contained relatively high levels of copper, calcium, potassium and

phosphorus. These results agree with those of Fellers *et al*. (1976), while lupine flour contained high amount of zinc, manganese and magnesium. High levels of iron were noticed in chickpeas flour. These results are in harmony with those obtained by Faheid and Hegazy (1991); Khorshid *et al*.(1996) and Salem *et al*.(1999).

2. Amino acid composition of ingredients used in tortilla chips fortification:

The amino acids composition of the ingredients is presented in Table (2). The results clearly indicated that the amino acids pattern differed according to the protein nature in the ingredient. Corn protein contained the highest level of proline (9.45gm/100gm protein) and lowest amount of threonine and Lysine. Lupine protein contained the highest level of serine, tyrosine and arginine of 5.44, 4.64 and 8.53gm/100gm protein, respectively. Chickpeas were rich in glutamic acid and histidine than lupine flour protein. Soybean contained the highest level of isoleucine, leucine, phenylalanine, and valine. Leguminous proteins are deficient in the sulfur containing amino acids (methionine and cystine), but contain higher amounts of all other amino acids in comparison with corn except proline. Results obtained are confirmed with those reported by Fahmy *et al*., (1981); Makhlouf (1984); Faheid and Hegazy (19991), Alam (1996); Salem *et al*. (1999) and Gafar (2000).

Table (2): Amino acid composition of corn, lupine, chickpea and defatted soybean flours (g/100g protein).

Amino acids	Maize	Lupine	Chickpea	Defatted soybean
Methionine (Met.)	1.80	1.05	1.82	1.97
Isoleucine (Ile.)	2.75	3.71	4.07	4.60
Leucine (Leu.)	6.20	7.05	6.40	7.88
Tyrosine (Tyr.)	3.70	4.64	2.92	3.75
Phenylalanine (Ph)	5.60	5.70	5.46	5.69
Histidine (His.)	2.55	2.90	4.01	4.80
Lysine (Lys.)	2.45	5.41	5.35	6.78
Arginine (Arg.)	3.41	8.53	7.47	7.97
Aspartic (Asp.)	6.30	10.64	9.09	11.12
Threonine (Thr.)	2.70	3.99	3.64	4.07
Serine (Ser.)	3.93	5.44	4.47	4.59
Glutamic (Glu.)	19.76	21.29	17.16	19.23
Proline (Pro.)	9.45	4.69	5.50	5.89
Glysine (Gly.)	3.64	4.42	4.51	4.90
Alanine (Ala.)	6.88	3.11	3.72	4.43
Cystene (Cys.)	1.75	1.82	1.05	1.94
Valine (Val.)	4.41	4.75	3.89	4.82

3. Chemical composition of tortilla chips produced from white corn and those supplemented with leguminous flours:

The chemical composition of tortilla chips and tortilla chips fortified with leguminous flours was determined and the obtained data are presented in Table (3). It could be noted that the moisture content of tortilla chips,

supplemented with legume flours relatively increased by increasing the supplementation level. This might be due to the water retention capacity of legume flours as reported by McWaters (1978) and Robert and Edith (1983). The highest moisture content of 2.62% was observed in the mixture containing 12% lupine flour.

Table (3): Chemical composition of white corn tortilla chips and tortilla chips fortified with leguminous flours (on dry weight basis).

Mixtures Compon-ents (%)	Control	Supplemented tortilla chips with								
		Soybean flour			Lupine flours			Chickpea flours		
		4 %	8 %	12 %	4 %	8 %	12 %	4 %	8 %	12 %
Protein	10.32	12.60	14.25	15.22	11.30	12.42	13.53	10.89	11.48	12.68
Fat	28.77	27.86	26.82	25.94	28.86	29.14	30.81	29.74	30.02	30.40
Ash	2.17	3.05	3.12	3.38	2.79	2.49	2.23	2.12	2.12	2.06
Fiber	2.98	3.05	3.08	3.11	3.09	3.15	3.15	2.54	2.31	2.36
T. C.	55.98	53.44	52.73	52.35	53.96	52.80	50.28	54.71	54.07	52.5
Moisture	1.55	1.62	1.75	2.02	1.65	1.83	2.62	1.75	1.91	2.08
Minerals (mg/100gm)										
Ca	240	245	251	259	238	228	225	236	230	226
Mg	130	130	126	122	136	142	142	125	127	120
K	157	181	199	226	141	137	135	123	145	156
P	220	230	257	280	236	249	260	218	230	221
Fe	3.90	4.2192	4.538	4.95	4.10	4.35	4.42	4.14	4.715	5.14
Mn	1.55	1.483	1.42	1.36	1.70	1.856	2.00	1.503	1.467	1.410
Zn	2.00	1.96	1.93	1.80	2.118	2.237	2.355	2.028	2.056	2.087
Cu	1.40	1.34	1.37	1.22	1.322	1.362	1.104	1.35	1.31	1.249

Where: T.C. = Total carbohydrate

The crude protein is the most important factor affecting corn quality. The different mixtures increased total protein content compared with control. Barron and Espinoza, (1993) found that fortified tortillas with chickpea flour showed a significant increase in nutritive value when compared to maize tortilla.

The total fat content increased in all mixtures except those containing soybean flour. The highest fat content was observed in mixtures containing chickpeas flour (0.09-2.04%). The rate of decrease of lipids level in mixtures containing soybean flour is due to the defatted soy flour used.

The ash content is 2.17% in control and is high in soybean-mixture, while it is nearly the same as control in both chickpea-mixture and lupine-mixture. Crude fibers content was 2.98% for control and increased continuously as the percentage of legume flours increased in all investigated mixtures, except the mixture containing chickpeas flour. The highest crude fiber content was observed in the mixtures containing soybean and lupine flour. This is mainly due to the effect of the high fiber content of soybean and lupine flour as reported by Faheid and Hegazy (1991). These results are in agreement with those reported by Hussein (1998) and Salem *et al*. (1999).

The mineral content of tortilla chips fortified with leguminous flours were extremely high as compared with control. This is expected to raise the nutritive value of fortified tortilla chips. It could be noticed that chips containing soy had relatively high levels of calcium, potassium and phosphorus. While chips containing lupine has higher amount of zinc,

manganese and magnesium. High levels of iron were noticed in chips containing chickpea. Results indicate also that mineral contents of chips increased with raising the level of supplementation. Hence, chips supplemented with legume flours are favorable than unsupplemented ones because of their high contents of important mineral. These results are similar to those observed by Bressani *et al*. (1990); Faheid and Hegazy (1991) and El-Akel and Hussein (1993).

4. Effect of supplementation with legume flours on the amino acids pattern of tortilla chips:

Table (4) shows the amino acids pattern of control tortilla chips and those supplemented with legume flours. Results showed that addition of legumes flours caused an increase in all amino acids content except sulfur containing amino acids which decreased because legumes are deficient in methionine and cystine (Tonella *et al*., 1983 and Faheid and Hegazy, 1991). Also, proline content decreased in all mixtures as compared with control.

Table (4): Amino acids composition of white corn tortilla chips protein supplemented with leguminous flours (g/100g protein).

Amino acid	Control	Supplemented tortilla chips with								
		Soybean flour			Lupine flours			Chickpea flours		
		4 %	8 %	12 %	4 %	8 %	12 %	4 %	8 %	12 %
Met.	1.80	2.1	2.4	2.6	1.8	1.7	1.60	1.8	1.80	2.00
Ile.	2.50	3.0	3.6	4.2	3.0	3.5	4.0	3.0	3.0	3.80
Leu.	5.70	6.26	6.50	6.80	6.10	6.48	6.97	6.04	6.52	6.72
Tyr.	3.60	3.60	3.50	3.6	3.2	4.1	5.1	3.4	2.8	3.0
Phy.	5.80	4.10	5.8	6.0	4.1	5.7	6.0	4.2	4.2	5.4
His.	2.70	3.00	3.2	3.50	2.9	2.8	3.5	2.9	2.9	3.3
Lys.	2.20	2.80	3.5	4.7	2.6	3.4	4.3	2.9	2.9	3.6
Arg.	3.20	3.9	4.8	5.7	4.6	5.7	6.8	4.2	4.7	5.8
Asp.	5.70	7.1	8.7	10.90	7.1	8.2	10.7	6.6	6.8	9.3
Thr.	2.60	2.6	3.5	4.30	3.6	4.0	4.4	2.6	2.8	4.0
Ser.	3.80	3.70	4.5	5.3	4.8	4.7	5.4	3.4	4.1	4.9
Glu.	20.30	22.2	24.4	26.9	23.1	26.9	29.2	21.4	21.2	20.0
Pro.	9.40	9.20	8.6	8.2	9.3	8.3	8.0	7.9	8.2	8.0
Gly.	3.70	4.2	4.8	5.1	3.9	4.70	5.0	3.9	4.2	5.0
Ala.	7.0	7.5	7.90	8.2	7.3	7.60	8.0	7.5	7.4	7.2
Cys.	1.70	1.9	2.1	2.4	1.90	2.1	2.3	1.8	1.9	1.6
Val.	3.61	3.80	4.20	4.70	3.60	4.40	4.60	3.60	3.90	4.0

Generally, the amino acid composition of each mixture was a result of the ingredients used. The supplementation of corn with lupine, chickpeas and soybean flours will evidently increase its protein content and will perusable enhance its amino acids content, except proline and those containing sulfur which showed a slight decrease. These results are inagreement with results reported by Serna-Saldivar *et al*, (1987); Faheid and Hegagy (1991) and Salem *et al.* (1999).

5. Mean Hunter color values of tortilla chips and tortilla chips fortified with soybean, lupine and chickpea flours:

Color is a major criterion that affects the quality of the final product. The fortified blends showed a difference in color in relation to the control. Slight improvement in color was interpreted as an intense cream color and it was dependant on the fortification level. Mean hunter color values of tortilla chips of different treatments are recorded in (Table 5). It was not considered to be a real disadvantage since even the commercial maize flours varies in color intensity according to the corn grains from which it is produced (Barron and Espinoza, 1993).

Table (5): Mean Hunter color values of white corn tortilla chips fortified with chickpeas, lupine and soybeans flours.

Tortilla chips made from	L	a	b	E
WC 10 (white corn)	79.98	0.77	23.74	83.43
WCS 1 (corn + 4% soybean)	79.2	1	24.3	82.85
WCS 2 (corn + 8% soybean)	79.5	1.50	25.62	83.54
WCS 3 (corn + 12% soybean)	79.7	1.53	23.3	83.05
WCL 1 (corn + 4% lupine)	80.3	2.3	25.3	84.22
WCL 2 (corn + 8% lupine)	80.4	2.5	25.8	84.48
WCL 3 (corn + 12% lupine)	80.6	2.6	26.4	84.85
WCC 1 (corn + 4% chickpea)	78.7	1	25.11	82.61
WCC 2 (corn + 8% chickpea)	78.4	1.32	26.3	82.70
WCC 3 (corn + 12% chickpea)	78.2	1.51	28.0	83.08

Increasing the percentage of leguminous flours added led to slight increase in the values of whiteness (L), redness (a), yellowness (b) and color index (E). Subjective evaluations confirmed that the chickpea was darker, more yellow and more greenish than control. When, lupine flour was added to the dough, the color become light. There results are in coincidence with these obtained by Hegazy *et al*. (1996). The tortilla color was gradually improved with increasing the levels of lupine flours. However, no significant difference was found between tortilla chips containing 4% lupine and these containing 8 and 12%. The color scores of tortilla chips containing soybean did not significantly change in comparison with those made form 100% corn. The total color of tortillas agreed with panelists judgement (Table, 5).

6. Effect of adding legumes flour on the quality WC10 tortilla chips:

Data in Table (6) represent the mean scores and their statistical indications for color, odor, taste, texture, crispness, appearance and acceptability for tortilla chips samples. Color is the one of the most important quality attributes of snacks products. The value of color was increased by adding of legumes flour as compared with control. No significant differences between control and supplemented tortilla chips in all parameters (odor, taste, texture, crispness, appearance and overall acceptability. Tortilla chips prepared with 4% and 8% defatted soybean flour was closely similar to the 100% corn flour dough in consistency and handing characteristics.

Results of sensory quality evaluations of tortilla chips were not affected adversely with addition of 4%, 8% and 12% of soy bean, chickpeas and lupine flours. It could be concluded that the best improvement were attained at addition of 8% defatted soybean flour, 4% lupine flour and 8% chickpeas flour.

Table (6): Sensory evaluation scores for tortilla chip fortified with leguminous flours.

Samples*	Sensory scores							
	Color (20)	Odor (20)	Taste (20)	Texture (10)	Crispness (10)	Appearance (10)	Acceptability (10)	Total (100)
WC 10	17.6	18.8	17.0	8.7	8.8	8.6	8.5	88
WCS 1	18.00	18.6	17.6	8.8	8.8	8.5	8.4	88.7
WCS 2	18.4	18.7	17.7	8.4	8.9	8.5	8.3	88.9
WCS 3	17.6	18.6	17.5	8.1	8.2	8.0	8.5	86.5
WCL 1	18.1	18.9	18.3	8.3	8.9	8.60	8.6	89.7
WCL 2	17.7	17.9	16.8	8.1	8.4	8.3	8.00	85.2
WCL 3	17.4	18.2	16.1	8.4	8.7	8.2	7.8	84.8
WCC 1	17.00	18.6	18.2	8.2	9.4	8.0	8.2	87.6
WCC 2	17.40	18.8	18.3	8.8	9.1	8.8	8.2	89.4
WCC 3	17.50	18.7	16.8	8.0	8.3	8.6	7.5	85.4
LSD at 0.05%	Ns	Ns	ns	ns	ns	ns	ns	ns

*** Refer to table (5)**

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إنتاج شيبسى الطرطية من الذرة / السورجم:
٦– جودة شيبسى الطرطية المدعم بالبقوليات

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تم اضافة دقيق فول الصويا منزوع الدهن والترمس والحمص الى عجينة الذرة المجلتنة (masa) بنسبة ٤و ٨و ١٢% من وزن الذرة . تم تحليل العينات لمعرفة محتواها من البروتين والاحماض الأمينية . يتميز شيبسى الطرطية المدعم بدقيق فول الصويا بارتفاع محتواه من البروتين والرماد والألياف والحديد والفسفور والبوتاسيوم والكالسيوم ومعظم الأحماض الأمينية . بينما تميز الشيبسى المدعم بالترمس بارتفاع محتواه من البروتين والألياف والماغنسيوم والحديد والمانجنيز والسريونين والأرجنين ، فى حين انخفض محتوى الشيبسى المدعم فى الاسبرتك والسيرين . أظهرت نتائج التقييم الحسى عدم وجود فروق معنوية بين العينات المدعمة والعينة المقارنة . والخلاصة فإن تدعيم شيبسى الطرطية بالبفوليات أدى إلى رفع القيمة الغذائية دون أن يؤثر على الخواص الحسية والتكنولوجية للمنتج النهائى.

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