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Shelf-life Studies on Osmo-Air Dried White Button Mushroom (*Agaricus Bisporus* L.)

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Abstract

White button mushroom (*Agaricus bisporus* L.) was subjected to osmotic dehydration at different concentrations of common salt (sodium chloride) i.e. 10, 15, 20 and 25% and sugar solution i. e. 50, 60 and 70°B and dried in hot-air oven at 55 ± 2 °C. There were about 31.2, 29.4, 27.2 and 24.4% reduction in weight with 10, 15, 20 and 25% salt solutions and 35.4, 38.3 and 38.8% with 50, 60 and 70°B sugar solution respectively. It took about 240, 220, 200 and 180 minutes to dry samples after osmotic treatment with 10, 15, 20 and 25% salt concentration and 240, 220 and 220 minutes with 50, 60 and 70°B sugar solution respectively. The untreated samples took about 340 minutes for complete drying. The colour was brighter for samples dried after OT with 25% salt and 70°B sugar concentrations having lowest optical density (OD) values. The dried products were packed in 200 gauge polypropylene bags and stored at ambient condition for one year. The chemical, microbial and organoleptic changes were monitored for one year. Storage study showed that there was marginal increase in moisture content and decrease in organoleptic quality of osmoa-air dried (OAD) mushroom slices. The samples dried after osmosis with 25% salt and 70°B sugar concentrations were found microbiologically safe and organoleptically acceptable up to one year of storage at ambient condition.

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Introduction

Mushrooms are edible fungi of commercial importance and their cultivation and consumption has increased substantially due to their nutritional value, delicacy and flavor[1]. White button mushroom (*Agaricus bisporus* L.) is the most widely cultivated species of edible mushrooms. It is a good source of high quality proteins, amino acids, vitamins (mainly vitamin C and vitamin B-complex), carbohydrates, dietary fibre and minerals, such as iron, calcium,

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phosphorous, potassium, selenium. It is highly perishable and has a short shelf life of 3–5 days at 2°C and around 1–2 days under ambient (Temp. 25 ± 2°C, RH 70%) conditions[2]. These can serve as a functional foods and as a source of drugs and nutraceuticals due to their antioxidant, antitumor and antimicrobial properties[3]. Because of their short shelf-life under normal ambient conditions of temperature and humidity, their preservation is of most importance[4]. Much work has been done on processing aspects of white button mushroom such as drying[5], preparation of soup powder[6], pickle[7], chutney[8], bakery products such as bread[9], biscuits[10] and its incorporation with other fruits and vegetables such as tomato-mushroom mixed ketch-up[11] and tomato-mushroom mixed soup[12].

Osmotic dehydration has received greater attention in recent years as an effective method for fruits and vegetables preservation. Being a simple process, it facilitates processing with retention of initial characteristics of fruits and vegetables viz. colour, aroma and nutritional compounds[13]. It is a technique of production of shelf-stable foods by placing the solid food in sugar or salt solution of high osmotic pressure and removal of moisture. It applies hurdle technique to solid foods without affecting their structural integrity[14]. Due to high concentration of TSS (Total soluble solids), dried product becames chemically stable. The other advantages include lower cost of packaging, storage and transport, decrease in bulk, so easy handling and availability in off-season[15]. Bchir, Besbes[16] reported that among all the preservation techniques osmotic dehydration is an economical and efficient from nutritional point of view. Yadav and Singh[17] concluded that it is one of the best and economical method for preservation because it does not deteriorate the nutritional ingredients and sensory characteristics such as flavor, color, and texture etc. also being preservative free, it does not adversely affect the human body.

During peak season, there is glut of mushrooms in the market but due to its perishable nature, it can not be stored for a longer period. Therefore, in order to minimize wastage and maximize its use, an effort has been made for development of osmo-air dried (OAD) mushroom slices. The study was undertaken to study the effect of different concentrations of osmotic agents *i.e.* salt (sodium chloride) and sugar on physico-chemical, organoleptic and microbial quality of OAD slices. Products were stored at room temperature (21-35°C) and changes in keeping quality were observed upto one year at 2 months interval.

Materials And Methods

Freshly harvested mushrooms (*Agaricus bisporus* L.) were obtained from a local mushroom farm, Hisar. Osmotic agents like sugar and salt were purchased

Table 1: Effect of different concentrations of salt and sugar solutions on dehydration and rehydration ratio of OADmushroom slices.

(a) Salt osmo-dried mushroom slices

Parameters	Concentration (%)					Mean	CD at 5%
	0	10	15	20	25		
Dehydration ratio	11.36	12.5	11.36	11.11	11.76	11.62	0.094
Rehydration ratio	2.18	2.33	2.22	2.25	2.12	2.22	0.087

(b) Sugar osmo-dried mushroom slices.

Parameters	Concentration (°Brix)				Mean	CD at 5%
	0	50	60	70		
Dehydration ratio	11.36	8.72	8.45	8.45	9.25	0.085
Rehydration ratio	2.18	2.55	2.42	2.46	2.4	0.097

from local market. White button mushroom were subjected to osmotic dehydration by two osmotic agents i.e. salt and sugar. In case of osmosis with salt, mushrooms after washing and draining were cut into 1.5 cm thick slices. These were then divided into eight lots. One lot was kept as control and other seven lots were given a combined treatment with 0.5% Potassium metabisulphite + 0.2% citric acid for 30 min for inactivation of enzyme polyphenol oxidase (PPO) responsible for browning in white button mushroom and used for osmotic treatment with salt/sugar solutions. Osmotic dehydration was done at concentrations of 10, 15, 20 and 25% salt solutions and 50, 60 and 70°B sugar solution with 100 g of mushroom slices in 400 ml of salt/sugar solution (1:4). Reduction in weight of mushrooms during osmosis was recorded at 1 h interval till it attained equilibrium stage (Fig. 1).

Osmotically dehydrated mushrooms (ODM) after draining were dried in hot air oven at 55 ± 2°C. Weight reduction during drying was noted at 15 min interval till the mushroom is completely dried. Loss in weight was plotted against time to get drying curve for mushrooms (Fig. 2). After complete drying mushrooms were taken out in desiccators and cooled. Thereafter, samples were finely packaged in 200 gauge polypropylene bags for further use in the study. Mushrooms dried in air without osmosis were taken as control. The dried products were stored at ambient condition (21-35°C) for one year. Dehydration ratio which is the ratio of weight of fresh mushrooms to the weight of dried mushrooms was determined[18]. Osmotic solutions were reused after concentration for fresh lot of mushrooms. Bolin, Huxsoll[19] reported that osmotic syrups could be re-concentrated and reused for osmotic water removal through at least five complete cycles without adversely affecting the quality of product.

For rehydration, OAD mushrooms were immersed in cold distilled water and allowed to get rehydrated. The rehydration ratio, which is the ratio of weight of sample after rehydration to the initial weight of dry matter, was determined[18]. The colouring matter in mushrooms was extracted with 60% ethanol and absorbance was measured at 440 nm using spectrophotometer[20]. Organoleptic evaluation of osmodehydrated slices was done using 9-point hedonic rating scale as described by Ranganna[18]. The data was tabulated and statistically analysed as per the method described by Snedecor and Cochran[21] using factorial CRD (Complete Randomized Design).

Table 2: Organoleptic evaluation of osmo-air-dried slices treated with different concentrations of salt and sugar solutions.

(a) With salt

	Concentration (%)						
Parameters	**0**	**10**	**15**	**20**	**25**	**Mean**	**CD at 5%**
Colour	2.23	5.50	7.00	7.50	7.90	6.03	0.376
Flavour	2.27	6.20	7.50	7.80	8.50	6.45	0.463
Texture	3.20	6.53	7.37	7.80	8.50	6.68	0.550
Overall acceptability	2.56	6.07	7.29	7.68	8.30	6.38	0.235

(b) With sugar

	Concentration (°Brix)					
Parameters	**0**	**50**	**60**	**70**	**Mean**	**CD at 5%**
Colour	2.23	7.20	7.50	8.20	6.28	0.675
Flavour	2.27	6.20	7.50	7.80	6.45	0.629
Texture	3.20	6.53	7.37	7.80	6.68	0.666
Overall acceptability	2.56	6.07	7.29	7.68	6.38	0.260

Results And Discussion

Weight reduction during osmosis of mushroom with different concentrations of salt is presented in Fig 1. It is observed that all the samples attained equilibrium stage after 6 hours. Rate of osmosis increased with increased concentration of salt solution. But at highest concentration of salt i.e. 25%, rate of weight reduction decreased which might be due to penetration of salt from medium to mushroom tissues thereby reducing the osmotic pressure. There was about 31.2%, 29.4%, 27.2% and 24.3% reduction in weight of mushroom samples treated with 10, 15, 20 and 25% salt solutions respectively. Therefore, highest weight reduction was observed in samples containing 10% salt concentration. Similar observations were recorded by Amuthan *et al*[22] in milky mushroom (*Calocybe indica*) during osmosis with salt solutions.

The effect of sugar concentration on dehydration of mushroom is depicted in Fig 1. The rate of dehydration of mushrooms increased with increase in syrup concentration. It is also clear that dehydration was rapid initially but decreased gradually with time because of dilution of syrup which was the result of movement of water from mushrooms to syrup. All the samples attained equilibrium stage after 6 hrs. There was 35.4%, 38.3% and 38.8% reduction in weight with 50, 60 and 70 °B sugar solution after osmosis. The results are in conformity with findings of Singh and Tomar[23] who recorded 42.24 % decline in weight

Table 3: Changes in overall sensory score of salt and sugar-treated air dried mushroom slices during storage

(a) Salt-treated

Concentration (%)	Storage period (Months)							
	0	2	4	6	8	10	12	Mean
0	2.56	2.61	2.6	2.62	2.5	2.51	2.53	2.56
10	6.07	6	5.95	5.9	5.9	5.8	5.72	5.91
15	7.29	7.32	7.3	7.27	7.25	7.23	7.2	7.26
20	7.34	7.7	7.68	7.5	7.41	7.41	7.35	7.48
25	8.3	8.2	8.2	8.12	8.1	8	8	8.13
Mean	6.31	6.37	6.35	6.28	6.23	6.19	6.15	
CD at 5%	Treatment = 0.412							
	Storage period = 0.488							
	Treatment × Storage period = 1.091							

(b) Sugar-treated

Concentration (%)	Storage period (Months)							
	0	2	4	6	8	10	12	Mean
0	2.56	2.61	2.6	2.62	2.5	2.51	2.53	2.56
50	7.44	7.36	7.36	7.32	7.3	7.2	7.2	7.31
60	7.76	7.7	7.64	7.6	7.5	7.4	7.3	7.56
70	8.4	8.3	8.3	8.26	8.22	8.2	8.16	8.26
Mean	6.54	6.49	6.48	6.45	6.38	6.33	6.3	
CD at 5%	Treatment = 0.045							
	Storage period = 0.059							
	Treatment × Storage period = 0.118							

during osmosis of mango slices in sugar solution. Water loss was observed highest in mushrooms treated with 10% salt and 70 °B sugar solutions. Similar results have been reported during osmotic dehydration of onions by Sagar[24].

Decline in weight reduction during osmosis was rapid initially but decreased gradually with time because of dilution of salt or sugar solutions by movement of water from mushrooms to syrup. Kar and Gupta[25] reported a rapid moisture loss during initial stages but decreased subsequently owing to decrease in moisture difference between the product and solution resulting in a lower driving force. They also demonstrated that choking of some of the pore spaces of button mushroom due to entry of salt into the tissues of mushroom resulting in obstructed movement of water from the center to surface of the mushroom.

Drying characteristics of osmotically treated samples in a hot air oven at 55°C are presented in Fig 2. It took about 180, 200, 220 and 240 minutes to dry the mushroom samples treated with 10, 15, 20 and 25% salt concentrations respectively. The untreated sample took about 340 minutes for complete drying. In case of sugar osmosis, time taken was about 240, 220 and 220 minutes to dry the samples treated with 50, 60 and 70°B sugar concentrations respectively. OAD method saved time of about 100-160 minutes in drying mushrooms than the one dried by air drying method only. Similar results were obtained by Kaleemullah and Kailappan[26] during OAD of papaya cubes and Amuthan and Visvanathan[22] during OAD

Table 4: Changes in browning (OD) of salt and sugar treated-air-dried mushroom slices during storage

(a) Salt osmo-dried mushroom slices

Concentration (%)	Storage period (Months)							
	0	2	4	6	8	10	12	Mean
0	0.35	0.42	0.45	0.52	0.56	0.61	0.73	0.52
10	0.23	0.24	0.26	0.29	0.29	0.31	0.32	0.28
15	0.18	0.22	0.25	0.27	0.28	0.29	0.3	0.26
20	0.16	0.2	0.22	0.23	0.25	0.27	0.28	0.23
25	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.16
Mean	0.2	0.24	0.26	0.29	0.31	0.34	0.37	
CD at 5%	Treatment = 0.014							
	Storage period = 0.017							
	Treatment × Storage period = 0.038							

(b) Sugar osmo-dried mushroom slices

Concentration (°Brix)	Storage period (Months)							
	0	**2**	**4**	**6**	**8**	**10**	**12**	**Mean**
0	0.35	0.42	0.45	0.52	0.56	0.61	0.73	0.52
50	0.18	0.22	0.24	0.27	0.28	0.3	0.31	0,26
60	0.14	0.21	0.24	0.26	0.28	0.29	0.3	0.25
70	0.12	0.2	0.22	0.23	0.25	0.27	0.28	0.22
Mean	0.2	0.26	0.29	0.32	0.34	0.37	0.41	
CD at 5%	Treatment = 0.021							
	Storage period = 0.027							
	Treatment × Storage period = 0.055							

of milky mushrooms.

Dehydration ratio of sugar-treated samples was higher (11.62) than salt treated (9.25) (Table 1). Rehydration ratio was recorded higher in case of sugar than salt OAD product which was mainly due to less shrinkage during drying in sugar OAD thereby resulting in higher uptake of water during rehydration. Further, rehydration ratio of all OAD slices was higher than that of control samples dried only by hot air oven method. Madan and Dhawan[15] also reported higher rehydration ratio of 3.28 in OAD carrot slices than 2.79 in hot air dried slices.

Organoleptic evaluation of OAD mushroom slices treated with different sugar and salt is presented in Table 2. There was significant difference in colour, flavour, texture and overall acceptability of products. Significant increase in overall sensory score of osmo-dehydrated products was observed with higher concentration of sugar and salt in osmotic solutions. Values for salt treated samples increased from 2.56 for control to 6.07, 7.29, 7.68, and 8.30 for 10, 15, 20 and 25% salt concentrations respectively. In sugar treated samples, values increased from 2.56 for control to 7.44, 7.76, and 8.40 for 50, 60 and 70 °B sugar concentrations. That was mainly because of the reason that higher concentration of sugar and salt prevented browning by inactivating enzyme PPO responsible for enzymatic browning in mushrooms thereby resulting in higher organoleptic score of products. Therefore, the osmo-dehydrated

Table 5: Changes in total plate count (CFU × 10/g) of salt and sugar OAD product during storage

(a) Salt OAD product

Concentration(%)	**Storage period (Months)**							
	0	**2**	**4**	**6**	**8**	**10**	**12**	**Mean**
0	0.3	1.5	3.5	6.8	8.8	10.2	15.2	6.61
10	-	0.5	1.5	2	2.5	4	6	2.75
15	-	0.4	1.4	1.8	2.2	3.5	4.2	2.75
20	-	0.4	1.3	1.6	1.8	3	3.5	1.93
25	-	0.3	1.3	1.4	1.6	2.2	2.8	1.6
Mean	0.3	0.62	1.8	2.72	3.38	4.58	6.34	
CD at 5%	Treatment = 0.201							
	Storage period = 0.220							
	Treatment × Storage period = 0.492							

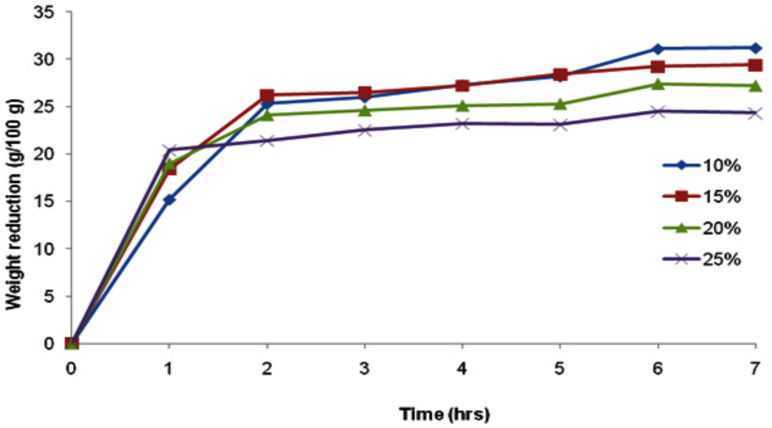
(b) Sugar OAD product

Concentration	**Storage period (Months)**							
(°Brix)	0	2	4	6	8	10	12	Mean
0	0.3	1.5	3.5	6.8	8.8	10.2	15.2	6.61
50	-	0.5	2	2.5	3.2	5	6.8	3.33
60	-	0.4	1.6	2.2	2.8	4.4	5.2	2.77
70	-	0.3	1.6	2	2.5	4.2	4.5	2.52
Mean	0.3	0.68	2.18	3.38	4.33	5.95	7.93	
CD at 5%	Treatment = 0.204							
	Storage period = 0.250							
	Treatment × Storage period = 0.499							

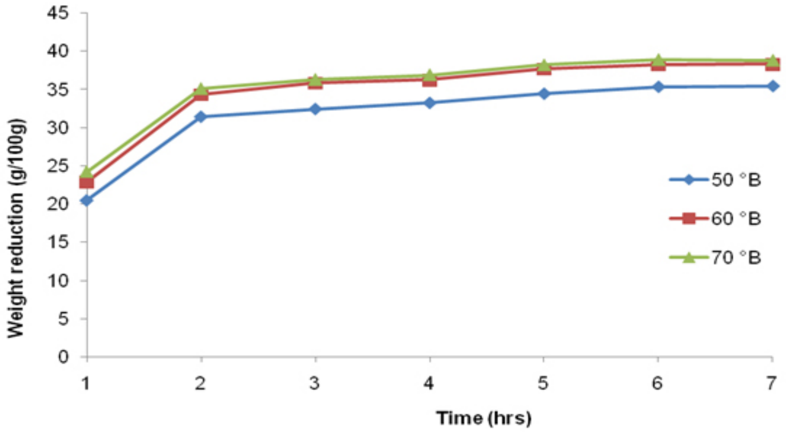
products treated with 25 % salt solutions and 70 °B sugar syrup scored highest for organoleptic quality parameters.

During storage, there was slight but non-significant decrease in overall organoleptic score of products (Table 3). This may be due to slight browning of the products during storage. Changes in values for organoleptic characteristics were, statistically non-significant. Narayana *et al*[14] reported no significant variation in the scores of colour, flavour, texture, taste and overall acceptability of osmo-dehydrated banana during storage. Madan and Dhawan[15] also reported non-significant decrease in the acceptability of dehydrated carrot slices during storage. However, slight decrease in colour/appearance was noticed during storage.

There was decrease in optical density (OD) values of products with increase in concentration of osmotic agents which was statistically significant (Table 4). Values decreased from 0.35 in control sample to 0.23, 0.18, 0.16 and 0.10 in samples treated with 10, 15, 20 and 25 % salt solutions respectively. In case of osmosis with sugar solutions OD value changed from 0.35 in control samples to 0.18, 0.14 and 0.12 in samples treated with 50, 60 and 70 °B sugar solutions respectively. Amuthan *et al* [22] reported that mushroom samples (*Calocybe indica* L.) treated with 25 % salt concentration had lower value for OD compared to other samples. During storage, there was significant increase in values for OD of OAD mushroom slices. Values increased from 0.20-0.37 for salt and 0.20-0.41 for sugar treated samples after one year of storage. Suguna, Usha [20] reported that OD value for fluidized bed dried mushroom



a



b

Fig. 1 (a-b):Weight reduction during osmosis of mushroom slices with different concentrations of salt (a) and sugar (b) solution

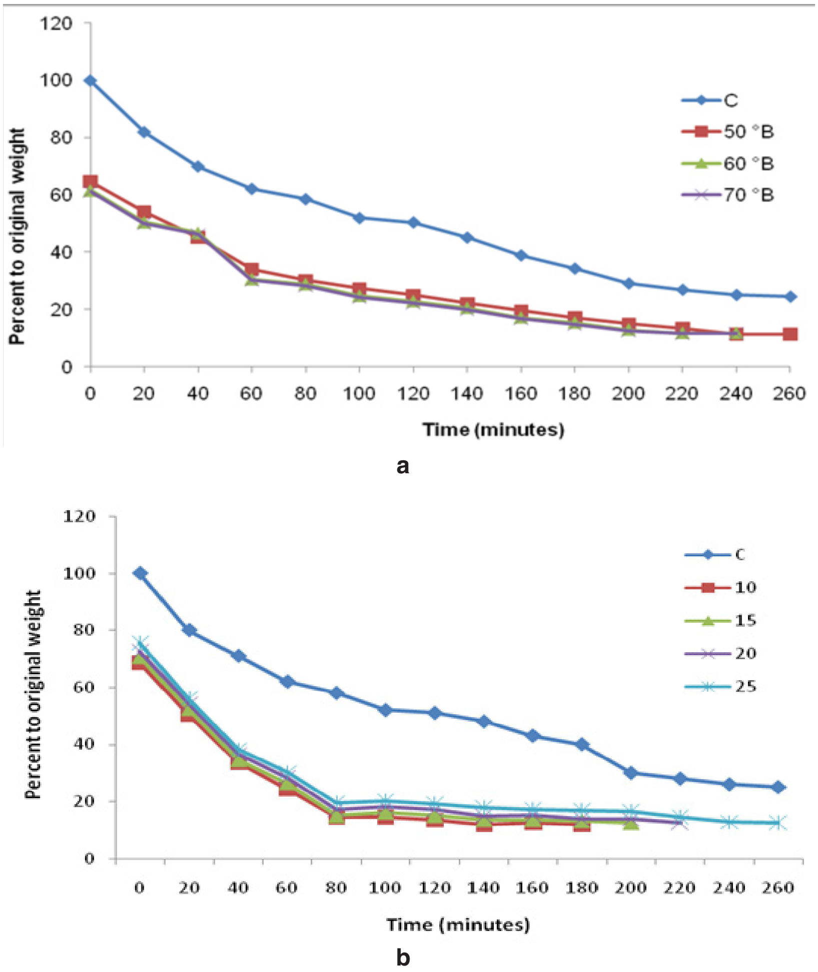


Fig. 2 (a-b): Drying characteristics of salt (a) and sugar (b) osmo dehydrated mushrooms

(*Pleurotus citrinopileatus*) increased continuously during storage for five months.

Changes in total plate count of products during storage are depicted in Table 4. Microbial count was nil in all treatments on zero day except for control where microbial count was 0.30 CFU × 10/g. Due to hygroscopic nature of products, there was slight increase in moisture content of samples which resulted in significant increase in total plate count of osmo-dehydrated products during storage. Values for microbial count increased from 0.30 CFU × 10/g on zero days to 6.34 CFU × 10/g after 12 months of storage in case of salt OAD products. In sugar OAD products, values increased from 0.30 CFU × 10/g to 7.93 CFU × 10/g which were statistically significant. Microbial growth was found less in samples treated with higher concentration of sugar and salt in comparison to control samples. Similar results were obtained by Narayana, *et al* [14] in osmo-dehydrated banana slices during storage.

Conclusion

It can be concluded that osmotic dehydration of mushrooms is an energy saving and quality improvement process. Mushroom slices could be successfully osmo-air dried using 25% salt and 70 °B sugar solution after giving a combined treatment with 0.5% Potassium metabisulphite + 0.2% citric acid for 30 min for inactivation of enzyme polyphenol oxidase. Osmo-dehydrated samples consumed less time and energy as compared to control samples during drying drying process as about 40% of moisture was removed during osmotic dehydration. Therefore, OAD saved time of about 100-160 minutes in drying mushrooms than air drying method. As osmotic agents *i. e.* salt and sugar can be reused, it is a cost effective process. OAD products showed better appearance, flavour, texture, taste and overall acceptability and could be stored for one year at ambient condition without any appreciable deterioration in quality.

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