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Functional properties of Syrian dried kishk effected by gamma irradiation treatments

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Abstract

This study investigated the physical and functional properties of Syrian dried kishk (SDK) treated with 0, 5, 10 and 15 kGy doses of gamma irradiation. Physical and functional analyses of SDK were evaluated immediately after irradiation. Used doses of gamma irradiation significantly increased Tap density (TD), carr index (CI), Hauser's ratio (HR), angle of repose, oil holding capacity (OHC), and solubility. While, the same doses of gamma irradiation (5, 10, and 15 kGy) reduced bulk density (BD), hydrophilic-lipophilic ratios (HLR), and least gelations concentration (LGC). Laboratory examination revealed that there were no significant changes between irradiated and non-irradiated groups in water holding capacity (WHC), swelling index (SI), swelling capacity (SC), foaming capacity (FC), foaming stability (FS), emulsion activity (EA) and emulsion stability (ES). Gamma irradiation showed slight, but significant effect on the physical and functional characteristics of SDK analysis, but the values of the analyzed parameters were still within the permissible limits approved by the national and international standards.

Keywords: dried kishk, functional properties, Gamma irradiation..

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1. Introduction

Nowadays, the changing dietary habit of consumers, who have little time to cook, but who want to follow a healthy diet, without having to spend a lot of time in the kitchen [1] Chemical and physical characteristics of food components contribute to the functional properties of the prepared or processed food product. Various technological processes including physical, chemical, enzymatic treatments, as well as the addition of additives have been used to modify functional properties of food and food products [2].

Dairy products are of great importance among traditional foods in Mediterranean countries including Syria, where people used processing traditional techniques to prevent milk and milk products spoilage [3]. Many fermented milks and its products were applied in order to preserve milk. The dried Kishk (DK) has been prepared in rural parts of Syria for many years. Like other types of dried products, DK is stored in many different ways for different periods of time and susceptible to infest by different kinds of store pests, and microorganisms during storage [4]. The kishk is also prepared in other regional countries with different names, Kashk (Iran), Zhum (Yemen), Kushuk (Iraq), Tarhana (Turkey), Kurut (Turkey) [5].

Traditionally, fumigation is used for disinfestations and 302epolymerisatio purposes; however, using chemicals for controlling store pests and microorganisms, that negatively impacts on the environment and store products [6]. As alternative methods, gamma irradiation has advantages in inhibiting the microbial growth in food, controlling the insect, remove the toxicity from food products, and enhanced its shelf life [7]. Gamma irradiation has been used for the disinfestation and decontamination of dried products due to its high penetrability into commodities [8].

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Previous studies indicated that the functional and nutritional properties of foods are improved due to radiation treatment [9]. Gamma irradiation also has a major influence on many functional properties of dried products via free radical mechanism which hydrolyzes the chemical bonds and break large molecules of starch into smaller fragments of sugars, dextrin's, and organic acids [10]. According to our bibliography, there is little information available on the literature on about effect of irradiation treatment on the functional properties of the locally prepared meals [11]. Also, until now, no scientific study has been reported in Syria and in the region about the functional properties of DK, and on the effect of gamma irradiation on the functional properties of DK. Therefore, the objective of the present study was to evaluate the effect of gamma-irradiation on the physicochemical and functional properties of Syrian dried kishk (SDK) that are homemade as traditional food by Syrian population..

2. Materials and methods

2.1. Preparation of the dried kishk

Syrian dried Kishk (SDK) is made at home and collected from Haran Al-awamid village, near Damascus, Syria, at 2021. Kishk was prepared according to the methods descript previously by Al-Bachir [12], by mixing yoghourt, parboiled cracked wheat (burghol), and salt. The mixing was fermented at 35 ºC up to 6 day, and dried in the sun for up to 7 days. The SDK samples were collected in polyethylene bags and kept at room temperature used later for laboratory analyses. Each bags of SDK (500g) was considered as replicate. The determination was done in triplicates for each measurement.

2.2. Irradiation process

Cobalt-60 at irradiator (ROBO, Russa) was used to irradiate the SDK at three different doses (5, 10, and 15 kGy). It is located at radiation technology department, Syrian atomic energy commission (SAEC), Damascus. For the experiment, an irradiation dose rate of 7.775 kGy h^{-1} was used. Irradiation performed at room temperature 18 – 25 ºC, and relative humidity (RH) of 50-70%. The absorbed dose was determined by alcoholic chlorobenzene dosimetry [4].

2.3. Determination of bulk density (BD), and tapped density (TD)

Bulk density was determined by the method of Oladele and Aina [13]. An amount of 50 g SDK sample was measured and put into a 100 ml measuring cylinder. The cylinder was tapped continuously in the palms of the hands until there was no more change in volume of the SDK in the cylinder. The BD was calculated as the weight of SDK (g) divided by the volume of SDK (ml).

For determination of TD, 50 g of SDK was gently tapped 150 times on a padded bench and the final volume noted. Tapped density was calculated using the relation:

$$\text{TD}\ (g/cm^3) = \frac{\text{Weight of sample}}{\text{Tapped volume}}$$

2.4. Determination of flow-ability and cohesiveness

The angle of repose, Hausner's ratio (HR), and Carr'sindex (CI) were used in estimating the flowability and cohesiveness of the SDK samples. CI was calculated according to the method described by Carr [14], from the bulk and tapped density data using the relation:

$$\text{CD}\ (\%) = \frac{(\text{TD} - \text{BD})}{\text{TD}} \cdot 100$$

Hausner's Ratio was calculated according to the method described by Hausner [15], as the ratio of TD to BD of the sample.

$$\text{HD} = \frac{\text{TD}}{\text{BD}}$$

Angle of repose was calculated according to the method described by Ohwoavworhua and Adelakun, [16]. A funnel was clamped with its tip 2 cm above a 9 cm wide Petri dish. The SDK samples were allowed to flow through the funnel until the apex of the cone thus formed just touched the tip of the funnel. The mean diameter (D), of the base of the powder cone was determined and the tangent of the angle of repose (θ), calculated using the relation:

$$\text{angle of repose}\ (°) = \arctan \frac{\text{H}}{\frac{d}{2}}$$

where; H is the height of the heap of powder.

2.5. Determination of water holding capacity (WHC) and oil holding capacity (OHC)

This was determined by the method of Sindhu and Khatkar, [17]. One gram (1 g) of SDK sample was combined with 10 ml of distilled water. The slurry was stirred occasionally with a glass rod over a 2 h period at 24°C. The slurry was centrifuged at 3250 rpm for 25 min in an ultracentrifuge (Ultra-Turrax T18 basic, IKA, Brazil) and the volume of decanted water was measured. The WHC was calculated as below:

$$\text{WHC (g/g)} = \frac{\text{Weight}_{\text{wet sediment}}\ \text{(g)}}{\text{Weight}_{\text{dry sample}}\ \text{(g)}}$$

For determination of OHC, method of method of Olu *et al.* [18] was used. One gram (1 g) of SDK sample was combined with 10 ml of sunflower oil. The slurry was stirred occasionally with a glass rod for 1 min at 24°C. The slurry was centrifuged at 4000 rpm for 20 min in an ultracentrifuge (Ultra-Turrax T18 basic, IKA, Brazil) and the volume of decanted oil was measured.

The OHC was calculated as below:

$$\text{OHC (g/g)} = \frac{\text{Weight}_{\text{oil absorbed}}\ \text{(g)}}{\text{Weight}_{\text{sample}}\ \text{(g)}}$$

2.6. Determination of Swelling Power (SP)

This was determined by the method of Potter and Hotchkiss [19]. An amount of 0.3 g (ms) of SDK was measured and dispersed in 10 ml of deionized water. The dispersion was heated under mild agitation at 80°C for 30 min in a thermostatically regulated temperature water bath (Shaking water bath–LSB-030S LabTEch-Korea). The gelatinized dispersion was centrifuged (Hettlich Zentrifugen, Typ 1000, Tuttlingen, Germany) at 2970 x g for 15 min. The mixture was allowed to stand for 3 h. The swelling index (SI) and swelling capacity (SC) were calculated using following formulas:

$$\text{SI} = Vol_{\text{sample after soaking}} - \frac{Vol_{\text{sample before soaking}}}{Weight_{sample}}$$

$$\text{SC (\%)} = \frac{Weight_{\text{wet sediment}}}{Weight_{sample}} \cdot 100$$

2.7. Determination of foam capacity (FC) and foam stability (FS)

This was determined by the method of Vinayashree and Vasu [20]. One and a half gram (1.5 g) SDK sample was whipped with 50 ml distilled water in a homogenizer (Ultra-Turrax T18 basic, IKA, Germany) Alaska blender (at high speed 24,000 rpm) for 2 min. The mixture was poured into a 250 ml graduated cylinder and the volume of foam at 30 s after whipping was taken as the foam capacity. The percent foam capacity was calculated as:

$$\text{FC(\%)} = \frac{Vol_{\text{after whipping}} - Vol_{\text{before whipping}}}{Vol_{\text{before whipping}}} \cdot 100$$

$$\text{FS(\%)} = \frac{Vol_{\text{after 120 min}\,standing} - Vol_{\text{before stirring}}}{Vol_{\text{before stirring}}} \cdot 100$$

2.8. Determination of Least Gelation Concentration (LGC)

Least gelation concentration was determined by the method of Sahni et al. [21]. Sample suspensions of 2% - 20% (W/W) 2% SDK (w/v at 1% increment) were made in 5 ml deionized water. The slurries were heated in screw-capped test tubes at in a thermostatically regulated temperature water bath (Shaking water bath–LSB-030S LabTEch-Korea) at 92°C with intermittent stirring. After 1 h of heating, the test tubes were immediately cooled in tap water for 2h. The minimum concentration at which the sample remained at the bottom of the tube when the tube was inverted was recorded as the least gelation concentration.

2.9. Emulsifying properties determination

The emulsifying properties of the SDK samples were 314epolyme according to the method described by Argel *et al.* [22]. To determine the emulsifying activity (EA), 1.5 g of SDK was dispersed in 30 mL of distilled water and homogenized at high speed 24,000 rpm of a homogenizer (Ultra-Turrax T18 basic, IKA, Brazil) for 2min. Then, 30 mL of soybean oil was added with further homogenization at 24,000 rpm f 2 min. The produced emulsion was centrifuged at 750×g for 5 min, the height of the upper phase was measured in the tube and expressed as a percentage in relation to the total height. The emulsion stability (ES) was evaluated by immersing the emulsion in a water bath at 80°C for 30 min, with subsequent centrifugation and measurement of the upper phase height, following the same procedure described for EA determination.

2.10. Statistical analysis

The data reported are averages of triplicate observations and mean ± standard deviation values are reported. An analysis of variance with a significance level of 5% was done and Duncan’s test applied to determine differences between means using the commercial statistical package (SPSS, Inc, Chicago, IL, USA)

3. Results and discussions

3.1. Effect of irradiation on bulk density (BD), and tap density (TD) of SDK

Bulk density (BD) of the control and irradiated SDK samples was in the range of 0.59-0.61 g/cm^3 (Table 1). BD of samples did not show large differences due to irradiation. SDK samples had the highest BD at 0, and 5 kGy (0.61 g/cm^3), whereas the lowest BD was observed in SDK sample treated with 15 kGy (0.59 g/cm3). Bhat *et al.* [23] reported that the BD of control and irradiated whole wheat flour samples were observed in the range of 0.50-0.57 g/mL, which is in agreement with the present study. BD depends on the samples' particle sizes, and it measures the heaviness of the starch sample [24]. It has been stated by Azim *et al.* [25] that the BD of the groundnut flour was not affected significantly by gamma irradiation.

However, TD of the SDK was higher than the BD ranged 0.76 g/cc, 0.77 g/cc, 0.78 g/cc, 0.78 g/cc, for 0, 5, 10 and 15 kGy doses. Higher TD is suitable to the packaging and the greater amount of material is packed with in a constant unit volume [26].

3.2. Effect of irradiation on Carr's index (CI), Hausner's ratio (HR), and Angle of repose of SDK

Carr's index (CI) and Hausner's ratio (HR) are a measure of the flowability and compressibility of a powder [27]. The values of CI for non-irradiated and irradiated SDK were ranged in between 19.68% and 24.35 % which was higher than the 15% (for good flowability). It means non-irradiated and irradiated SDK indicate that poor flowability. The score of CI (%) of 5–10, 12–16, 18–21 and 23–28 represent excellent, good, fair and poor flowability [28]. Hausner ratio of the samples was found to be higher than 1.25 (for good flow). It seems that the HR indicates that poor flow property of both the starches. HR value less than 1.25 indicates good flow and greater than 1.25 indicates poor flow [27].

Angle of repose of untreated SDK sample was 28.59. Gamma irradiation treatment increased significantly ($p<0.05$) the angle of repose of SDK to reach 33.30. 32.62, and 33.77 for SDK samples treated at 5, 10, and 15 kGy, respectively. Porosity is one of the main indicators that determines the quality of bakery products and characterizes their structure, volume and level of

Table 1. Effect of gamma irradiation on Physical properties of Syrian dried Kishk (SDK) product

Parameters	Control	5 KGY	10 KGY	15 KGY
Bulk Density (BD) (g/cm3)	0.61±0.002a	0.61±0.002a	0.61±0.002b	0.59±0.001c
Tap Density (TD) (g/cm3)	0.76±0.003d	0.77±0.001c	0.78±0.004b	0.78±0.003a
Carr Index (CI) (%)	19.68±0.28d	20.36±1.20c	23.10±1.11b	24.35±1.07a
Hausner's Ratio (HR)	1.25±0.004d	1.26±0.02c	1.30±0.02b	1.32±0.02a
Angle of repose	28.59±0.03d	33.30±0.05b	32.62±0.42c	33.77±0.56a

abc Means values in the same column not sharing a superscript are significantly different.

3.3. Effect of irradiation on water holding capacity (WHC) and oil holding capacity (OHC) of SDK

Water holding capacity (WHC) and oil holding capacity (OHC) of irradiated and non-irradiated (control) SDK samples are presented in Table 2. WHC of the SDK samples treated with 0, 5, 10, and 15 kGy was 269.61, 264.66, 269.23, and 265.36%, respectively. In contract with our results Wani *et al.* [29] reported that, the WHC increased significantly ($P<0.05$) with increased the doses of irradiation due to the degradation of the starch into simple sugars (like glucose, dextrin etc.) which had higher affinity for water than starch. WHC deals with the size, shape, proteins, lipids, pH and salt [30]. These results agree with the results of Munir *et al.* [31], which reported that this increase in WHC might be due to higher amylase activity on the damaged starch along with the production of higher levels of reducing sugars. The changes in WHC of irradiated samples could be attributed to crosslinking of polymers which may have occurred simultaneously with chain scission [32].

OHC was found to increased significantly ($p < 0.05$) in irradiated samples. It was found in the range of 86,38-104.15% for irradiated and non-irradiated SDK samples. The highest OHC was seen in SDK samples irradiated with 5 kGy (104.15%), and the lowest OHC was detected in SDK in the control samples (86.38%). OHC shows the binding capacity between fat and protein for the manufacturing of the food products. The physical properties of irradiated food products refer to the changes that occur due to exposure to ionizing radiation, and the most common material changes are associated with texture, as well as WHC [33]. Irradiation can affect the WHC of meat products by causing protein structure changes [34]. When starch was treated with irradiation which may cause the denaturation of protein and disintegrate the physical structure of amylopectin chain and unfolding of proteins [35]. Therefore, the starch had the ability to entrap/bind the oil. Irradiation might have caused denaturation of proteins and aggregation of unfolded proteins causing a decrease in OHC [23].

3.4. Effect of irradiation on hydrophilic lipophilic ratios (HLR), and solubility of SDK

The HLR of SDK was observed to decrease due to irradiation doses. It increases from 3.13 in control sample to 2.55, 2.85, and 2.73 for samples treated with 5, 10, and 15 kGy, respectively (Table 2). Whereas, water solubility index of SDK was observed to increase with the increase in irradiation doses (5-15 kGy). It increased from 13.10 in control sample to 13.49, 14.02, and 15.72%, for 5, 10, and 15 kGy, respectively (Table 2). This could be attributed to breakage of glycosidic bonds of starch and decrease in inter-chain hydrogen bonds contributing to increased polarity [36]. The soluble indexes are the leaching of the degraded amylose and amylopectin characteristics after maximum swelling; therefore, the samples that experienced more severe radiation-induced damage (contained smaller starch fractions) tended to be more soluble, the molecular breakdown of the starch caused by irradiation was the cause of the rise in solubility of the irradiated cassava starch [24]. The increase in the solubility was due to the increase in the polarity because of chain scission under irradiation and the decrease in interchain hydrogen bonds [36].

Table 2. Effect of gamma irradiation on Water Holding Capacity (WHC) (%), Oil Holding Capacity (OHC) (%), Hydrophilic-Lipophilic Ratios and Solubility (HLR) (%) of Syrian dried Kishk (SDK) product.

Parameters	Control	5 KGY	10 KGY	15 KGY
Water Holding Capacity (WHC) (%)	269.61±30.04a	264.66±1.46c	269.33±4.93a	265.36±4.31b
Oil Holding Capacity (OHC) (%)	86.38±3.26d	104.15±5.28a	94.52±2.37b	97.52±8.96c
Hydrophilic-Lipophilic Ratios (HLR)	3.13±0.15a	2.55±0.14d	2.85±0.12b	2.73±0.21c
Solubility (%)	13.10±0.74d	13.49±0.34c	14.02±0.01b	15.72±0.05a

abc Means values in the same column not sharing a superscript are significantly different.

3.5. Effect of irradiation on dispersibility and swelling properties of SDK

Dispersibility percentage of the control and irradiated SDK samples was in the range of 55.17-58.83% (Table 3). Dispersibility percentage of SDK samples did not show large differences in-between the used doses of gamma irradiation treatments. SDK samples had the highest dispersibility percentage at 15 kGy (58.83%), whereas the lowest dispersibility percentage was observed in SDK sample treated with 10 kGy (55.17%). Upon irradiation, the swelling power including; swelling index (SI) and swelling capacity (SC) of the SDK noticeably reduced with the increasing irradiation dose (Table 3). The SI of SDK treated with 0, 5, 10, and 15 kGy were, 2.81, 2.75, 2.80, and 2.68, respectively. Whereas, the SC of SDK treated with 0, 5, 10, and 15 kGy were, 428.38, 423.97, 424.47, and 421.54%, respectively. This indicates the severe 316epolymerisation of some of the amylose and amylopectin molecules. Once the amylopectin structure is disrupted, an intact linkage cannot be formed, and the damaged chains tend to dissolve because they no longer can entrap water [37], and the destabilization of the hydrogen bonds within the double helices of the starch under medium and high-dose of irradiation treatment [38].

Table 3. Effect of gamma irradiation on Dispersibility (%), Swelling Index (SI), Swelling Capacity (SC) (%) and Least gelation concentration (LGC) (%) of Syrian dried Kishk (SDK) product.

Parameters	Control	5 KGY	10 KGY	15 KGY
Dispersibility (%)	57.83±0.29b	56.17±0.29c	55.17±0.76d	58.83±0.29a
Swelling Index (SI)	2.81±0.02a	2.75±0.07b	2.80±0.08ab	2.68±0.05c
Swelling Capacity (SC) (%)	428.38±9.02a	423.97±1.19b	424.47±5.25b	421.54±3.12c
Least Gelation Concentration (LGC) (%)	18.00±0.01a	10.01±0.01b	6.00±0.01c	4.00±0.01d

abc Means values in the same column not sharing a superscript are significantly different.

According to Yeboah *et al.* [37], hydrolysis has been found to cause changes in the swelling power of starch morsels.

3.6. Effect of irradiation on least gelatinization concentration (LGC) of SDK

The least gelatinization concentration (LGC) is the least percentage of concentration needed to form a gel in a starch. The LGC of the irradiated SDK was gradually decreased with the increasing dose of gamma radiation (Table 3), The gelatinization for 0, 5, 10 and 15 kGy treated SDK were found to be 18.00 %, 10.01 %, 6.00 and 4.00%, respectively. In related with our results, Liu *et al.* [36] found the decreases in the gelatinization of irradiated maize starch were not statistically significant from 0 to 20 kGy, but a significant decrease was observed from 20 to 50 kGy. Also, Chung *et al.* [39] reported insignificant differences for the gelatinization of irradiated normal corn starch from the native counterpart at 1, 5, and 10 kGy, while a significant decrease was found at 25 and 50 kGy. According to Chung and Liu [40], gelatinization temperatures reflect the stability of starch crystallites. Comparatively gamma irradiation doses, may cause the disruption of the crystalline domain in starch granules, as well as the disruption of the double-helical order [41].

3.7. Effect of irradiation on foaming properties of SDK

Food foam are related to the surface activity and film forming capacities of protein molecular, and foaming ability is depend on the rate that which the surface tension of the air water interface decreases [11]. As indicated in Table 4, the apparent foaming capacity (FC) of the SDK samples treated with 0, 5, 10, and 15 kGy were 9.00, 10.67, 9.67, and 10.00%, respectively. FC of SDK samples did not show large differences between uses doses of irradiation. SDK samples had the highest FC at 5 kGy (10.67 %), whereas the lowest FC was observed in SDK sample treated with 0 kGy (9.00%).

Regarding the foaming stability (FS), our results showed that gamma irradiation did not affect the FS of SDK. The FS for SDK samples treated with 0, 5, 10, and 15 kGy were 98.33, 99.00, 97.67, and 99.00%, respectively. Several researchers also indicated that gamma radiation caused no significant changes in foaming stability of soybean and velvet bean seeds [42]. In contrast with our results, several researches indicated that gamma irradiation increased FC and FS of food products [43]. It suggested that irradiation usually decomposes the protein and fat particles in irradiated products which may enhance the foaming capability [11].

3.8. Effect of irradiation on emulsifying properties of SDK

Emulsifying activity (EA) is defined as the maximum amount of oil that can be emulsified by a fixed amount of the protein, while ES is defined as the rate of phase separation in water and oil during storage of the emulsion [44]. The effect of gamma irradiation processing on the emulsifying properties o SDK is described in Table 4. The EA for 0, 5, 10 and 15 kGy treated SDK were found to be 47.60%, 48.39%, 47.60 and 44.73% respectively. Whereas, the ES of SDK treated with the same dose (0, 5, 10, and 15 kGy) were 42.77, 45.70, 45.46, and 43.69, respectively. The EA and ES of the SDK showed no significant ($p < 0.05$) change when they treated at the dose up to 15 kGy (Table 4). Several researches indicated that gamma irradiation has a different effect on the emulsifying properties of the food products. These differences could be attribute to the genetic variation, protein profile and gamma doses [11]. Present study revealed that the properties of EA and ES were did not changed after irradiation. In various studies showed that a good emulsifier acts as a barrier against lipid oxidation. Ahmed *et al.* [6] found that gamma irradiation significantly reduced the EC of sorghum flour. In contrast, radiation process enhanced the EC of soybean seeds and sunflower seeds [42, 45].

Table.4 Effect of gamma irradiation on Foaming Capacity (FC) (%), Foaming Stability (FS) (%), Emulsion activity (EA) (%) and Emulsion Stability (ES) (%) of Syrian dried Kishk (SDK) product.

Parameters	Control	5 KGY	10 KGY	15 KGY
Foaming Capacity (%)	9.00±0.01d	10.67±0.58a	9.67±0.58c	10.00±0.01b
Foaming Stability (%)	98.33±1.16b	99.00±0.01a	97.67±0.58c	99.00±0.01a
Emulsion activity (%)	47.60±2.11b	48.39±1.61a	47.60±2.11b	44.73±0.50c
Emulsion Stability (%)	42.77±1.45d	45.70±0.93a	45.46±2.57b	43.69±1.30c

abc Means values in the same column not sharing a superscript are significantly different.

4. Conclusions

As a response to the growing consumer This study explored the effect of 5, 10, and 15 kGy doses of gamma irradiation treatment on the physical and functional properties of SDK. Analyzing all SDK samples, it was determined to have the best physical and functional qualities. Based on our study it can be stated that the applied doses of gamma irradiation, that recommended for decontamination of dried food, can preserve, maintenance, and (Ultra-Turrax T18 basic, IKA, Brazil) improve the safety and functional properties of SDK. Further investigations on the effect of gamma irradiation on functional properties of prepared meal require further investigation.

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Conflict of interest statement

The author declares no conflicts of interest.

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