Effects of Date Pit Powder Inclusion on Chemical Composition, Microstructure, Rheological Properties, and Sensory Evaluation of Processed Cheese Block

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Abstract Date pit powder (DPP) as a promising by-product additive from date palm (Phoenix dactylifera L.) was recovered as a novel fat replacer fiber source in processed cheese block type (PCB). Four concentrations of cheese fat replaced by DPP (0, 5, 10, 15, and 20%) in PCB were conducted and its impact on chemical composition, microstructure, rheological and sensory properties was evaluated. The inclusion of DPP was improved the fiber content and texture properties of PCB. The DPP stabilized the cheese hardness, adhesiveness, and springiness with fat replacement in cheese. The microstructure of replaced fat PCB with DPP showed lesser numerous fat globules and has a smooth and homogenous protein embedded and distributed uniformly throughout the cheese structure compared to the control. The replacement of 5% fat in PCB by DPP recorded the closest rated sensorial evaluation comparing with control in all criteria and acceptance scores. Regarding the obtained results, date pit as a novel by-product from dates may have a potential texture property and could enrich fiber content and bioactivity of PCB.

Keywords: dietary fiber enrichment, date pit powder, processed cheese block, fat replacement, processing, microstructure, texture, sensory

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1. Introduction

Saudi Arabia considered one of the global leaders in the production of dates. Annual date production in Saudi Arabia was more than 9 million tons [1]. Dates harvested from the farms are processed producing approximately 12-15% of fruit weight according to the date fruit type - as non-edible residues and rich in high-value compounds known as “pit” [2,3]. Date pits are an odorless and excellent source of fiber than the fleshy parts of the date fruits [4,5]. Also, pits are good source of fiber that can be constituted to provide gelling agents for food industry. Date pit should therefore be explored for economic value in food industry and other sectors such as nutraceutics and pharmaceutics [6,7]. Averages of chemical compositions of date pit as reported in most researches was 7.5% dry matter, 6% moisture, 8.5% protein, 8% fat, 15% crude fiber, 60% carbohydrates and 1.5% Ash [8,9]. Regardless fibers The Date pit have bioactive components such as polyphenols which make it a potential value adding and functionality in food products [10]. The functionality and structural properties of date pit are promising and potential for many value added as for oil contents [11], fibers and bioactive components such as phenolic compounds [12]. On the other hand, date pit potentiality have thermal characteristics [8], antioxidant activities [13,14,15], antiviral activities [16], and nutritional values [10,17]. The functional and constituent features of date pit have also given it promising applications in the field of some food industries. Few studies indicated that date pit enable to be good alternative substitute of dietary fiber in bread enrichment [4], Coffee-substitute in hot beverages [18], Ketchup [19], Stimulant drinks [3], preservative in minced meat and burger [20,21] and jam production [22,23]. The presence of significant amount of fibers, proteins, fats, and carbohydrate content in date pit powder functionally make it potential nutritionally for supporting food products. In addition, odorless, stability, anti-oxidative and higher fiber content makes DPP a good nutraceutical and pharmaceutical ingredient [24,25]. The challenge for the recovery of date pit is to find the appropriate process technologies able to achieve the new functionality without compromising the stability and functionality of the obtained compounds. Therefore, DPP could be appointed as novel natural additive for food use. Incorporation of
enormous varieties of non-dairy ingredients into processed cheese has become a research objective to innovate its novel functionality toward texture and health properties [26,27,28]. The necessity of developing the processed cheese industry urges manufacturers either to reduce the price by always searching for cheaper ingredients mainly from plant sources to replace milk fat either totally or partially [29]. Cheese consumers are showing an increasing demand for additives that are healthy and free from chemical additives. Application of DPP as natural additive in cheese was not reported before. To expand date pit applications in cheese it is possible to incorporate in PCB (Kraft type). Heat treatment and tins canning of processed cheese will hypothesized enhance incorporation of date pit into processed cheese. It would diversify the functions and nutritional features of processed cheese through new ingredients provided such as fiber. Therefore, the study aimed to recover the date pit as a high value dates byproduct as novel fat replacer in PCB and evaluation of changes in chemical composition, texture characteristics, microstructure, phenotypic, sensory and microbial characteristics of partially fat replacement processed cheese with DPP.

2. Materials and Methods

2.1. Materials

Standard cheddar cheese (Fat/dry base 55.8 and protein 25.1%), Frozen cheddar cheese (Fat/dry base 54.2 and protein 24.2%), Milk fat butter (81.7% fat, 1.4 SNF) were obtained from Fonterra Inc., New Zealand. Emulsifying salt Joha C Special obtained from BK Giuliani, Germany. Antibacterial agent, Nisin (E234) obtained from Danisco, Denmark. Antifungal agent, Potassium sorbate obtained from Nutrinova, Germany. Local khalas type of DPP (Phoenix dactylifera L.) obtained from Al-Ahsa Eastern Province, Saudi Arabia.

2.2. Methods

2.2.1. Preparation and Analysis of Date Pit Powder

Date pit powder was prepared according to [8,10]. Khalas type of date pit were washed, and oven dried at 50°C for 48 hours, crushed, and milled using (Guangzhou Mingyue - China) grinding mill, then sieved into 300 μm filter. Proximate composition of Fat, Protein, Total solids, Moisture, Ash and Total fiber content were determined in triplicate according to AOAC’s official methods [30]. On the other hand, plate count agar medium at 32°C/ 48 hrs. for total viable bacterial count and violet red bile agar medium at 37°C / 24 hrs. for Coliform as well [31]. Nutrient agar medium at 37°C used for aerobic spores forming bacteria count [32]. Potato dextrose agar medium were incubated at 25°C / 5 days for molds and yeasts count [33].

2.2.2. Cheese Ingredients and Experimental Design

Cheddar cheese and other ingredients (Table 1) were used for production of PCB with different percentage of DPP. The four treatments were designed via control treatment mixture by replacement 5, 10, 15, 20% of its cheese mixture butter by DPP.

2.2.3. Preparation of Fat Replaced Processed Cheese Block

Full fat (T₀ treatment), 5% reduced-fat (T₁ treatment), 10% reduced-fat (T₂ treatment), 15% reduced-fat (T3 treatment), and 20% reduced-fat (T₄ treatment) PCB were prepared according to the formulations given in Table 1. Treatment Blends were prepared at 85°C with continuous stirring at 700 rpm for 5 minutes using a 2 kg capacity batch Stephan UMSK05 Cooker as reported by [34]. Following production, cheese blocks were packed in tins and stored at ambient temperature (25±2°C). Samples were for chemical, microbiological, textural and sensorial assessments. Microstructure evaluation was carried out by using scanning electron microscopy.

2.2.4. Chemical Composition and pH

Total nitrogen of DPP (khalas type) used in the present study was detected using the Kjeldahl method [35], factor of 6.25 was used to calculate protein amount. The moisture was determined by oven-drying at 105°C to constant weight [35]. Total fiber content was determined using the method of [36]. Total carbohydrate was calculated by difference of fat, protein and ash contents from the total solids of date pit. Fat replaced cheeses were analyzed for moisture, fat and salt contents according to the methods of [35]. Total protein was determined according to the method described by [37]. Kjeldahl Semi-automized Foss model 8100 Dairy Analyzer (FOSS analytical, Hilleroed, Denmark) was used. Salt content determined by Corning chloride analyzer 926, Spain. The pH was assessed in cheese slurry (20 g of cheese in 20 ml of distilled water) using pH meter (Crison instrument, Spain). Titratable acidity according to [38].

2.2.5. Color measurements

The color of the fat replaced processed cheese block was determined according to Wadhwani and McMahon [39] using Hunter colorimeter Model D2s A-2 (Hunter Assoc. Lab. Inc. Va, USA) following the instruction of the manufacturer [40]. Instrument was standardized using a white tile (top of the scale) and a black tile (bottom of the scale). A specimen of the cheese (flat layer) was placed at the specimen port; the tri-stimulus values of the color namely; L, a and b were measured where: L: value represents darkness from black (0) to white (100), a; value represents color ranging from red (+) to green (-) and b value represents yellow (+) to blue (-).

2.2.6. Texture profile analysis

Texture profile analyses were determined using Brookfield Texture Analyzer (Model CT3 4500, USA). Pre-test speed, Test Speed, Trigger type and deformation were 1.5mm/s, 2mm/s, 2.5g and 5mm respectively. The following parameters were evaluated by Texture profile analysis (TPA) according to the definitions given by the International Dairy Federation [41]. Hardness, is nominated as the force required to attain a given deformation; fracturability is the force at which the material fractures; springiness or elasticity is defined as the rate at which a deformed material goes back to its un-deformed condition after the deforming force is removed and cohesiveness is defined as the quantity simulating the strength of the internal bonds making up the body of the product.
2.2.9. Statistical Analysis

1 to 5 as described by [43]. Replaced fat cheeses were assessed independently by a score panel of experienced and trained personnel belong to the staff members of food and nutrition science department, King Faisal University and evaluated using a Five-hedonic scale from stickiness, break down, gumminess, smoothness and

2.2.8. Sensory Evaluation

Sensorial attributes including appearance, firmness, stickiness, break down, gumminess, smoothness and chewiness were evaluated using a Five-hedonic score scale from 1 to 5 as described by [43]. Replaced fat cheeses were assessed independently by a score panel of experienced and trained personnel belong to the staff members of food and nutrition science department, King Faisal University.

2.2.7. Cheese Scanning Electron Microscopy

The microstructure of replaced fat PCB (treatments T1 - T4), control (T0) and DPP were evaluated using scanning electron microscopy (JEOL - Japan Electron Optics Laboratory - JSM-6380 LA) for fresh product at ambient temperature. Cheese samples were prepared according to [42]. Cheese cubes 3x3x3 mm were cut from the center portion of cheese fixed in solution consist of (4% formaldehyde, 1% glutaraldehyde) in 0.1 mol/l phosphate buffer solution pH 7.2 at 4°C for 3 h. Cubes were post fixed in osmium Tetra-oxide 2% (v/v) in the same buffer at 4°C for 2 h. Samples were washed in phosphate buffer and dehydrated successively at 4°C through a graded (20, 40, 60, 80, 95%, and 100%) series of ethanol. Cubes were then defatted twice in chloroform for 15 min each and returned to absolute alcohol. Specimens were critical-point dried by CO2. Each dried specimen was fractured to expose the internal structure, mounted on a copper stub and coated with gold up to a thickness of 400 Å in a sputter-coating unit. Resolution 3.0 nm (30kV, WD8mm, SEI), Accelerating voltage 0.5 to 30 kV (53 steps) and Magnification x5 to 300,000 (149 steps) were adjusted.

2.2.6. Chemical Composition and pH of Fat Replaced PCB Treatments

Table 3 reveals changes in the chemical composition, acidity and pH of fat replaced PCB treatments (T1, T2, T3, T4) by DPP instead of butter fat added with replacement ratio 5, 10, 15 and 20 %, respectively comparing with full fat cheese (T0 treatment). pH and acidity not affected by incorporation of DPP in cheese blends on the day of manufacture. All replaced fat PDT moisture content was decreased (P≤ 0.05) compared with control one. Cheese treatments T2 and T3 had 2.6 and 2.48% lower moisture per protein ratio. Moreover, the reduction in the moisture/protein ratio in fresh processed cheese sample lead to an increase in pH value. The fat content of T1, T2, T3 and T4 cheeses were 28, 27.33, 27.0, 26.16 %, respectively, which correlate to fat reduction of approximately 28% in T0 cheese. Although, DPP (18.44% fat) which replaced fat) did not appear to significantly change fat content of 5,10,15 and 20 %, respectively comparing with full fat cheese (78% fat) did not appear to significantly change fat content of processed cheese (78% fat).

Table 2. Ingredients and experimental design of fat replaced processed cheese block

| Ingredients/gm | T0 | T1 | T2 | T3 | T4 |
|----------------|----|----|----|----|----|
| Milk fat butter | 207 | 196.7 | 186.3 | 176 | 166 |
| Date pit powder | 0 | 10.35 | 20.70 | 31.50 | 41.40 |
| Frozen cheddar cheese | 600 | 600 | 600 | 600 | 600 |
| Standard cheddar cheese | 1080 | 1080 | 1080 | 1080 | 1080 |
| Emulsifying salt Joha C Special | 54.6 | 54.6 | 54.6 | 54.6 | 54.6 |
| Nisin | 0.234 | 0.234 | 0.234 | 0.234 | 0.234 |
| Potassium sorbate | 2.34 | 2.34 | 2.34 | 2.34 | 2.34 |
| Water including condensate | 400 | 400 | 400 | 400 | 400 |

T0- control; T1: 5% fat replacement; T2: 10% fat replacement; T3: 15% fat replacement; T4: 20% fat replacement.

2.2.9. Statistical Analysis

Statistical analysis were carried out by using complete randomized design according to [44] by SAS software package, version 9.1.3 [45]. Differences between means of treatments tested by DUNCAN test at P< 0.05 were statistically significant.

3. Results and Discussion

3.1. Characterization of Date Pit Powder

The chemical composition of date pit which used shown in Table 2. The study by [46,47] indicated that date pit consist of 80-78% total dietary fiber, 7.1-3.1% moisture, 6.4-2.3% protein, 13.2-0.5% fat and 1.8-0.9% of ash. On the other hand, Platat et al [10] indicate that date pit (khalas type) contained 5.84% protein, 72.72% total dietary fiber and 7.92% fat [10]. Most of the fibers matched to the insoluble portion [48]. High levels of dietary fiber in various varieties of date pit have encouraged the technical enhancement of it in PCB as functional replacement for fat [45,49].

Table 2. Chemical and microbial analysis of date pit

| Contents                     | g/100 gm |
|------------------------------|----------|
| Fat                          | 18.44±1.72 |
| Protein                      | 4.86±0.58  |
| Total solids                  | 90.61±3.0086 |
| Moisture                     | 9.39±0.10  |
| Ash                          | 1.36±0.0086 |
| Total fiber                  | 65.95±0.67 |
| Total Plate Count (CFU/gm)   | <15       |
| Coliform (CFU/gm)            | 0         |
| Yeast & Mold (CFU/gm)        | <12       |

3.2. Chemical Composition and pH of Fat Replaced PCB Treatments

Table 3 reveals changes in the chemical composition, acidity and pH of fat replaced PCB treatments (T1, T2, T3, T4) by DPP instead of butter fat added with replacement ratio 5,10,15 and 20 %, respectively comparing with full fat cheese (T0 treatment). pH and acidity not affected by incorporation of DPP in cheese blends on the day of manufacture. All replaced fat PDT moisture content was decreased (P≤ 0.05) compared with control one. Cheese treatments T2 and T3 had 2.6 and 2.48% lower moisture per protein ratio. Moreover, the reduction in the moisture/protein ratio in fresh processed cheese sample lead to an increase in pH value. The fat content of T1, T2, T3 and T4 cheeses were 28, 27.33, 27.0, 26.16 %, respectively, which correlate to fat reduction of approximately 28% in T0 cheese. Although, DPP (18.44% fat) which replaced fat) did not appear to significantly change fat content of 5,10,15 and 20 %, respectively comparing with full fat cheese (78% fat) did not appear to significantly change fat content of the resultant cheeses. Protein contents of T1, T2, T3 and T4 cheeses were 28, 27.33, 27.0, 26.16 %, respectively, which correlate to fat reduction of approximately 28% in T0 cheese. Although, DPP (18.44% fat) which replaced fat).
3. Color Measurements

Color intensities of fat replaced PCB varied and could be described as yellow-brown (Figure 1). Among the full-fat cheese T0 was more yellow in appearance shown the highest b* value (P < 0.05), and lacked redness (i.e., low a* value). The visible appearance of cheese treatments (Figure 1) showed a clear difference compared to the control one. The color gradually shifted as a result of adding pit powder from the yellowing of the control sample to light brown with increasing concentration of DPP. The color intensity of this cheese differed and could be characterized as yellow-brown. Among the full-fat cheese T0 had the most yellow in appearance shown by having the highest b* value (P < 0.05), and lacked redness (i.e., low a* value).

On the other hand, color measurements of fat replaced PCB with DPP illustrated in Table 4 and Expression of color parameters was subjected in CIELAB color space. Statistically significant effect of date pit inclusion in processed cheese as fat replacer was found in all cheese treatments compared with control. With gradual increment of DPP addition L* value found gradual decreasing which were 80.9 for T0 and 64.4 for T4 and that variance shown Significant difference at (p > 0.05). That changes may refer to increment of fiber content which agreed with [51,52].

3.4. Texture Profile Analysis

As results revealed in Table 5, hardness 1.2 (g) for date pit PCB treatments, ranged between 574.3 and 732.6 which lower than control one. DPP addition to PCB decreasing hardness gradually (P≤ 0.05). DPP showed a major water holding capacity (more than 1.5 times its own weight) and a moderate oil holding capacity (OHC) [21]. The moisturizing property may provide a good texture and led consequently to be firmer than control and could be due to the high content of protein. As a result of citrus fruits containing pectin cellulose and hemicellulose, they affect the increase in hardness [55]. The structure of the processed cheese became more compact and therefore harder because of water content supplied to a finished product. On the other hand [56] reported that the addition of 5% oat fiber particles to model cheese containing milk fat 51% and canola oil 49% resulted minor increases in hardness. [57] and [58] observed the addition of the tested hydrocolloids decreased product hardness. Matrix plasticisation because of protein hydration, may the reason of that effects. [59] reported that hardness of the fat replacers (corn dextrin and polydextrose) in processed cheese not affected for all treatments. Fat replaced processed cheese with variant starches in amylose and amylpectin ratio showed five-fold increase in hardness via two-fold of amylpectin starch [60] and [61]. And also for fat replaced processed cheese with rice bran revealed increases in hardness [43].

Adhesiveness results of fat replaced PCB treatments with DPP were very close to control one (P < 0.05). It varied between 0.15-0.183 for date pit cheeses via 0.2 for control one. According to Akasha et al. [53] DPP may considered a good emulsifying ingredient, polysaccharides (as glucans, xylans, cellulose, and mananns) associated in date pit proteins enhance functional properties, raise their capability as an emulsifier. [62] reported that addition of 1% acacia, bamboo and potato fiber into processed cheese was the highest adhesiveness value comparing with other treatments. Contrariwise, with using inulin and soy fiber to the processed cheese analogues, [63] and [58] noticed a decrease in adhesiveness. The phase separation may related to decrease of adhesiveness [64]. Reduced-fat cheeses with added bulgur showed significant increases in values for hardness and chewiness, while values for cohesiveness, springiness and gumminess did not significantly differ from those determined for control cheese [50].

![Figure 1](image.png)

**Figure 1.** Visual appearance of fat replaced processed cheese block with date pit powder.
Table 4. Color measurements of fat replaced processed cheese block with date pit powder (n = 3)

| Color Measurements | T0               | T1               | T2               | T3               | T4               |
|--------------------|------------------|------------------|------------------|------------------|------------------|
| L                  | 80.96±0.661b     | 72.90±0.85b      | 68.95±2.54b      | 65.86±4.73b      | 64.45±3.01b      |
| a                  | -3.34±0.035d     | 0.52±0.1c        | 2.34±0.32b       | 3.66±0.82a       | 4.24±0.23a       |
| b                  | 22.66±1b         | 18.22±0.43b      | 16.34±0.20b      | 16.65±0.52b      | 14.31±0.35b      |

Values in the same row with different superscripts are significantly different (p ≤ 0.05).

T0: control; T1: 5% fat replacement; T2: 10% fat replacement; T3: 15% fat replacement; T4: 20% fat replacement.

Table 5. Rheological measurements of fat replaced processed cheese block with date pit powder (n = 3).

| Rheological Measurements | T0               | T1               | T2               | T3               | T4               |
|--------------------------|------------------|------------------|------------------|------------------|------------------|
| Hardness 1(g)            | 768±108.9a       | 717.5±32.9a      | 732.6±75.6a      | 636.5±210.9a     | 657.6±115.6a     |
| Hardness 2(g)            | 665.8±94.7a      | 646±23.8a        | 699.16±62.09a    | 574.3±204.5a     | 604.16±112.2a    |
| Adhesiveness(mJ)         | 0.2±0.005a       | 0.18±0.017a      | 0.183±0.07a      | 0.15±0.04a       | 0.18±0.005a      |
| Springiness(mm)          | 6.1±0.45a        | 6.3±0.208a       | 7.5±2.1a         | 6.56±1.38a       | 5.56±0.32a       |
| Cohesiveness             | 0.58±0.07a       | 0.61±0.01a       | 0.75±0.18a       | 0.63±0.106a      | 0.58±0.026a      |

Values in the same row with different superscripts are significantly different (p ≤ 0.05).

T0: control; T1: 5% fat replacement; T2: 10% fat replacement; T3: 15% fat replacement; T4: 20% fat replacement.

Springiness and cohesiveness values were lower in control treatment than those of other date pit treatments. However, they greatly increased with increasing the added ratio of date pit in the formula of cheese particularly in T1 and T2. That result of springiness and cohesiveness agreed with Nateghi et al. [57] by using xanthan gum and Awad et al. [54] by using lupine.

3.5. Cheese and Date Pit Powder Microstructure

Cheese casein, fat, minerals, moisture, soluble solutes such as lactose, lactic acid, and salts represents the locative distribution of cheese microstructure (Richoux et al 2008). Replaced fat PCB with DPP of fresh cheese treatments were scanned at previous magnitude at ambient temperature (Figure 2). Date pit particles appeared as polymer matrix composite matched with oat fiber as reported by [18]. It acts as breakers in the microstructure of replaced fat cheese. Microstructure of control treatment (T0) showed spherical voids representing space of fat globules that were extracted during sample preparation. Replaced fat block-type processed cheeses with DPP (T1 - T3) could be described lesser numerous fat globules and as a smooth and homogenous protein were embedded and distributed uniformly throughout the cheese structure as compared with control. It revealed distribution in protein matrix, larger fat globules that were uniformly distributed throughout the cheese structure as compared with date pit-free cheese (T0). In addition, the surface of protein matrix of T4 appeared to be coarse and the matrix itself was less distribution and denser compared with T1-T3 cheeses. These modifications could be attributed to the emulsification capacity and protein binding ability of date pit. This structure appeared to have low electronic density and might be due to the fiber content of date pit. The microstructural characteristics of date pit-free cheeses made are in agreement with those previously reported for processed cheese [65]. Replaced fat cheese treatments (T1 - T4) appeared lower diameters in protein matrix with fat globules compared to fat globules in control (T0) and distributed unevenly. Noronha et al., [66] report that the resistant starch as fat replacers in cheese absorb water, that exhibited an intensive protein matrix in protein micelle. McMahon et al., [67] reported that the fat replacement may interpose with shrinkage of the protein micelle and reduce the force involved in drive out water from curd Madadlou et al. [68], indicate that Fat globules interrupt the protein chains by giving the desired creamy texture of the product. The fat lowering in cheese create more compaction in the protein matrix, thus increasing its hardness and adhesiveness. Concerning the microscopic screening, it was founded that date pit processed cheese treatment T2 (5% fat replacement) and T3 (10% replacement) is more effective on microstructure and in appearance comparing with control one.

Figure 2. Scanning electron micrograph (SEM) of date pit powder. A: 100X; B: 300X; C: 500X; D: 1000 X
3.6. Sensory Evaluation

Sensory evaluation of fat replaced PCB with DPP toward appearance, flavor, firmness, stickiness, and breakdown, gumminess, smoothness, chewiness and Overall acceptances showed in Figure 4. Treatment T₁ (5% fat replacement) was the best rated evaluation in all criteria and differences in appetences scores were not significant. Panelist’s description was highly reflected with color of the fiber in PCB. Due to insoluble particles, despite good texture, it is not rated well for its looks especially with an increase date pit. Sensory evaluation of color confirms the tendency of color variance correlated with date pit addition, measured by instrumental analysis, but it gives an overall judging for color which may explain the significance of sensory values. Schädle et al. [59], indicates that adding fat replacers fibers meeting future demand for low-fat products with appealing sensory features.
Figure 4. Sensory evaluation of fat replaced processed cheese block with date pit powder (n = 3). Values in the same row with different superscripts are significantly different (p ≤ 0.05). T0: control; T1: 5% fat replacement; T2: 10% fat replacement; T3: 15% fat replacement; T4: 20% fat replacement

4. Conclusion

Date pit could be considered as a potential non-cheese ingredient in fat replaced PCB, improving their texture and increasing their fiber content. In general, replacement 5% and 10% of fat replaced PCB by DPP would be the closest to the control. Date pit could have significant potential additive to enrich cheese with fiber with minimum impact on cheese composition, texture, microstructure, and sensorial attributes.

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