

The perspectives of fresh-cut fruits and vegetables on the Zagreb market

Abstract

The fresh-cut fruits and vegetables (FCFV) are defined as products that have been trimmed and/or peeled and/or cut into 100% usable product that is bagged or pre-packaged to offer consumers a high nutrition, convenience and flavor while still maintaining its freshness. Fruits and vegetables (FV) are abundant with phytochemicals that indicate beneficial influence on human health when consumed frequently and as a part of daily diet. Healthy conscious consumers appreciate convenience of FCFV, but due to its extreme perishability sometimes their quality and safety may be questionable leading to its shortened shelf-life. Optimal processing as well as distribution conditions are imperative for prolonging their shelf-life. Hence, the prototype of vending machine (VM) for FCFV which could replace usual salad bars in food services and maintaining the highest hygiene criteria was constructed by funding of the BICRO-project and implemented at Faculty of Food Technology and Biotechnology University of Zagreb. In the first part of this study, performance of VM prototype in the cold storage of fresh-cut (FC) apple during 7 days was investigated and interest for FCFV by oral survey with Zagreb citizens was examined in the second part. Quality and sensory characteristics of FC apples stored in VM remained satisfactory for 4 days and microbial analysis showed that VM could provide a safe product for 7 days. Furthermore, the need for such device confirmed the tendency of consumers to choose their own FCFV combinations and purchase such products near the workplace. In general, market analysis proved increased consumers demand for FCFV.

Keywords: fresh-cut fruits and vegetables, fresh-cut apples, vending machine, microbial analysis, market analysis

Introduction

The International Fresh-cut Produce Association (IFPA) defines fresh-cut fruits or vegetables (FCFV) as products that have been trimmed and/or peeled and/or cut into 100% usable product that is bagged or pre-packaged to offer consumers high nutrition, convenience, and flavour while still maintaining its freshness (International Fresh-Cut Produce Association, 1999; Lamikarna, 2002). Due to its convenience fresh-cut (FC) products in comparison to whole fruits and vegetables (FV) are products with added value but extremely perishable at the same time. FC industry is constantly growing as a response of increased consumers' demand for FCFV, particularly in developed countries (Jideani et al., 2017; Sidiqiu et al., 2011) where modern lifestyle and less time for meal preparing prevail (Abadias et al. 2008) along with the number of health-conscious consumers who understand a role of food in maintaining well health status and risk reduction of numerous diseases (Ragaert et al., 2004). FV are abundant with phytochemicals that indicate beneficial influence on human health when consumed frequently and as a part of daily diet minimally 5 times per day in total amount of minimally 400 g (Cox et al. 1998) or even seven times and more (Oyebode et al., 2014). However, consumers' food choice is corre-

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lated with convenience of purchasing and consummation (Ragaert et al., 2004; Verlegh and Candel, 1999) and therefore FCFV is desirable product on the market. Its processing includes washing, cutting, peeling, optionally anti-browning treatment, removing surface moisture by gentle centrifugation or in air-flow and adequate packaging without any thermal treatment. Mechanical injury of the tissue caused by processing alters FV physiology, accelerates enzyme activity and microbial growth, what consequently reduces quality, safety and in general shelf-life of products (Sidiqui et al., 2011). To maintain the quality and to ensure safe products at least 5-7 days required in retail (Sidiqui et al., 2011), hygienic working conditions and optimal storage temperature (not higher than 8 °C) are crucial (Jideani et al., 2017; Artés-Hernández et al., 2013).

Generally, FCFV products are classified in two main classes according to the modified classification given by Laurila and Ahvenainen (2002): FC products with shelf-life of 1-5 days (usually produced in kitchen conditions with ordinarily hygienic requirements and are usually intended for restaurants, catering and other food services) and FC products intended for retail (shelf-life should be minimally 5-7 days). Such products are produced in industrial facility with extremely high hygienic requirements. Besides, FCFV products differ by packaging type due to its purpose (Table 1).

Table 1. An overview of FCFV products upon packaging, intention and point of sale
Tablica 1. Pregled FC voća i povrća ovisno o pakiranju, namjeni i mjestu prodaje

Packaging	Contain amount for	Point of sale	Intention
Bags*	one or more meals	retail	consumption at home or ready for cooking
Boxes	one meal	retail, food services, vending machines	consumption out of home
Bags-gastro pack	more meals	retail, wholesale	used in: catering, restaurants, food services

*-mostly vegetables; Source/Izvor: Private categorization/Vlastita kategorizacija

Usually, vegetables packaged in bags contain amount of more than one meal and consumers buy them in retail with intention to eat it at home as a side dish or salad. It is not intended for consumption directly from bags with few exceptions, e.g., baby carrot. Fruits are usually not packaged in bags, except apples, contain amount for one meal and are intended for the consumption outside home. Products packaged in boxes, usually for one meal and equipped with fork are produced to fulfill consumers demands for ready to eat meal as a FV-based meal or snack. The most convenient places to buy such products are the retails, fast food services and vending machines near the workplace or at some frequent places. Besides these two packaging types, gastro pack exists to facilitate and shorten cooking and serving process duration in restaurants, hotels, food services, etc.

In Croatia, production of FC started twenty-five years ago with bags-gastro packs (Table 1) of lettuce (especially iceberg). Nowadays, FC production in Croatia is experiencing a great progress, where besides aforementioned gastro packs, various types of lettuce [mostly iceberg (*Lactuca sativa*), salad rocket (*Eruca sativa*), lamb's lettuce (*Valerianella locusta*), red and green chicory (*Cichorium intybus*) and baby spinach (*Spinacia olerace*)] packaged in smaller bags for retail as well as vegetable based ready to eat meals are produced.

According to the best of our knowledge, although there are several FC producers in Croatia, just one of them has a facility with specific industrial equipment where hygienic conditions can ensure 7 days shelf-life of final ready to eat products. Furthermore, there are no accurate data on FC production in Croatia, but according to the data collected by the courtesy of one of the Croatian FC producers, sale of FC vegetables in bags increased more than 10 times in the last ten years. Although production and consumption of FC vegetables as ready to eat meal in boxes are more frequent in the Croatian market in the last few years, there is still a lot of space to improve and expand this market offer, especially considering fruits and all types of FC products listed in Table 1. FC fruits on Croatian market is really scarce. Such products can only be found in supermarkets or certain small food services. In both cases, they are mostly produced under kitchen conditions. Sometimes FCFV are served in the salad bars, having some advantages in comparison to packaged FC linked to the benefit of own choice of FV kind and less utilization of plastic boxes. On the other side, maintaining the high hygiene conditions is demanding and offered FCFV extremely fast deteriorate and thus should be used in very short time.

Accordingly, prototype of a vending machine (VM) which could replace usual salad bars in food services along with the maintenance of the highest hygiene criteria was constructed and implemented at FFTB in Zagreb by the funds of the project Program of Proof of concept by HAMAG-BICRO (Croatian Agency for SMEs, Innovation and Investments established by the Government of the Republic of Croatia). The purpose of this VM was to store unpackaged and separately placed several FCFV types in the same hermetically closed chamber under controlled atmosphere and optimal temperature, equipped with appropriate mechanism for taking out certain portion of FV directly without disordering temperature/atmosphere conditions inside the chamber. This prototype differs from usual vending machines which offer FCFV packaged in plastic boxes. Aforementioned VM prototype placed in food service could overcome salad bars' disadvantages and it could provide customers' own selection of various FV types as well as portion size with less plastic boxes utilization along with prolonged shelf-life and less deterioration with remarkable reduced microbial contamination.

Therefore, this study had two goals: a) to investigate the performance of VM prototype in maintenance of FC apple quality, sensory and microbial safety during storage, and b) to examine the interest of Zagreb citizens for FCFV by oral survey.

Materials and methods

For experiment purpose, apples cv. Crisp Pink purchased from the market were used. Undamaged and uniform fruits were selected, washed by tap water and manually peeled with apple peeler. Apples were cut into 8 pieces with apple stainless steel cutter and obtained pieces were halved by sharp knife. One batch of prepared pieces was used as control (C) and the second batch was anti-browning treated (ABT). Namely, immediately after cutting, samples were dipped in aqueous solution of ascorbic acid (1%, w/v) and citric acid (0.2%, w/v) (Gram-mol d.o.o., Zagreb, Croatia) for 3 min at 18 °C (sample (g)/solution (mL) ratio=1:4), decanted and gently shaken in plastic colander to remove surface moisture. Prepared samples (C and ABT) (approximately 3 kg of each batch) were put into the VM prototype's basket and stored for 8 days in hermetically closed chamber under controlled atmosphere (average composition was 11.5 % O₂ and 10.5 % CO₂) and temperature 5±1°C. After 1, 2, 4 and 7 days approx. 300 g of each batch samples (C and ABT) was taken out by special mechanism without disordering chamber storage conditions.

Initially and after each storage day, quality parameters, sensory properties and microbial counts of the samples were analyzed. About 5-6 pieces were homogenized with kitchen stick mixer (CNHR9EV, Bosch, Slovenia) and obtained pureé was used for soluble solids (SS; °Bx) measuring by refractometer (PAL-3, ATAGO, Japan).

Texture analysis of firmness were conducted by texture analyzer (TA.HD.plus Texture Analyzer, Stable Micro Systems, UK), where three pieces from each sample were tested in triplicate ($n=9$) using 4 mm stainless-steel punch probe with 6 mm penetration distance, speed of penetration 0.5 mm s^{-1} with pre-test speed 1 mm s^{-1} and test speed 10 mm s^{-1} . Firmness (N) was calculated as the maximum force achieved during probe penetration into the sample.

Color analysis were done by measuring color parameters L^* [lightness, (0-100)], a^* [redness (+) to greenness (-)] and b^* [yellowness (+) to blueness (-)] of three pieces of each sample using colorimeter (Spectrophotometer CM-3500d, Konica Minolta, Japan) with 8 mm diameter hole measuring plate and black cylinder cover. Color parameters were triple recorded for each slice ($n=9$). Total color difference (ΔE) was calculated from sum of square of difference between each of the L^* , a^* , and b^* values in reference to the C/0-day sample.

Sensory evaluation was carried out by 7 participants from the faculty staff and students, frequent apple consumers, previously trained in two hours' session. They were instructed about necessary technical information as well as examined sensory attributes (color, taste, texture, overall acceptability) and its assessment using bipolar 9-point hedonic scale (9-extremely like to 1-extremely dislike, where 5 was neutral and was marketability limit) (Aguayo et al., 2006; Gil et al., 1998). Color was evaluated in terms of browning as well as taste and texture as intensity of apple taste and firmness, respectively. Samples were evaluated on the day of analysis, immediately after taking it out of VM on the porcelain plate.

With the sensory evaluation, immediately after taking pieces out of VM sampling for microbial analysis was done as well. Total mesophilic count (aerobic mesophilic bacteria count, AMB) was performed according to the HRN EN ISO 4833-1:2013 (ISO 4833-1:2013, EN ISO 4833-1:2013). Ten g of sample was mixed with 90 mL peptone saline solution in a sterile stomacher bag and homogenized for 1 min using a Stomacher. Dilutions were made in peptone water as needed for plating. Plate Count Agar was used as the media for AMB counts pour plate, incubated at $30 \pm 1^\circ \text{C}$ for 3 days. Total yeast count was performed according to the HRN ISO 21527-1:2012 (ISO 21527-1:2018) methods for enumeration of yeast and molds with Dicloran Rose bengal chloramphenicol (DRBC) agar with incubation at $25 \pm 1^\circ \text{C}$ for 5 days. Sample preparation procedure was the same as for total AMB. Analysis were carried out in two replicates ($n=2$).

In order to examine the interest and attitudes of citizens regarding FCFV, oral survey in Zagreb (downtown streets and shopping malls) in 2013 was conducted. Eight students (seven females and one male) were engaged as the interviewers and were previously educated in two hours' session about FCFV and a questionnaire. Respondents (308) were randomly selected among passersby who were willing to participate in the survey. The questionnaire included several questions about FCFV in general, buying/non-buying reasons and circumstances, but only the crucial ones are selected for the results presentation: questions regarding the structure of the respondents (gender and age), habitual consumption of FV generally as well as FCFV, the maximum price of FCFV and could consummation of FCFV as a snack substitute sweets consummation. Furthermore, respondents who consumed FCFV were asked about circumstances that would encourage them to more frequent purchase (the possibility of choosing the composition of such product and the possibility of buying it near the workplace). Respondents who did not consume FCFV were asked about reasons for not buying it (suspicion in health safety and excessive price).

Results regarding FC apple storage were statistically analyzed by analysis of variance (ANOVA) and marginal means were compared using Tukey's test at significant level $p \leq 0.05$. Frequencies and distributions were calculated for the survey results analysis.

Results and discussion

Table 2 presents quality characteristics of examined FC apple samples. All analyzed samples were significantly different upon all tested quality parameters, except firmness (Table 2). SS were in range of values usual for apples (Putnik et al., 2017a) although slightly lower related to usual values for cv. Cripps Pink whole fruit (Eisenstecken et al., 2008; Kovač et al., 2007). SS depend on harvest time, climatic conditions, growing area (Kovač et al. 2007) as well as storage conditions and duration (Eisenstecken et al., 2008). Also, analyzed apples in this study were FC apples as in Altisent et al. (2014) study, where similar SS were reported. As it can be seen, SS were slightly higher in ABT samples as well as SS increased during storage, what could probably be due to water loss that occurs as a result of facilitated transpiration of peeled and sliced pieces (Toivonen and DeEll, 2002). Firmness and color values were also in accordance with Altisent et al. (2014) results. Expectedly, L^* decreased with storage duration but slower in ABT samples since anti-browning agents are efficient in browning reduction (Altisent et al., 2014, Putnik et al., 2017a). Moreover, other color parameters, especially a^* and ΔE , also showed the browning occurrence during storage, but values of both parameters were significantly lower in ABT samples. It can be observed that ΔE generally increased with storage time. However, these values were almost twice higher in control samples as compared to ABT (9.51–12.16 vs. 3.47 – 6.02). According to Yang (2012) subjective perception of color difference for $\Delta E=3-6$ is appreciable, while for $\Delta E=6-12$ is much perceptive. Applying this criterion on ΔE ranges for C and ABT samples it can be concluded that color difference of ABT samples was visible but it remained pretty similar during all 7 days and the effectiveness of anti-browning agents in browning prevention is clearly confirmed (Putnik et al., 2017a).

Table 2. Quality parameters of FC apples during 7 days storage

Tablica 2. Parametri kvalitete FC jabuka tijekom 7 dana skladištenja

Sample/ Uzorak	d ^a	SS/TST (°Bx)	Firmness/ Tvrdoa (N)	L^*	a^*	b^*	ΔE
		p<0.01*	p=0.35	p<0.01*	p<0.01*	p=0.02*	p<0.01*
C	0	12.1±0.3 ^a	4.2±0.6 ^a	80.83±1.27 ^c	-1.15±1.98 ^{ab}	18.10±1.98 ^{ab}	-
ABT	0	12.7±0.3 ^{ab}	4.6±0.7 ^a	80.71±1.97 ^c	-1.24±3.39 ^a	15.89±3.39 ^a	3.63±1.75 ^a
C	1	12.2±0.3 ^a	3.8±0.5 ^a	75.01±1.44 ^{ab}	3.07±2.69 ^c	26.60±2.69 ^{ab}	11.10±1.65 ^{de}
ABT	1	13.0±0.3 ^{abc}	3.8±0.6 ^a	79.00±1.54 ^{bc}	-0.20±3.11 ^{ab}	19.80±3.11 ^{ab}	3.47±0.72 ^a
C	2	12.5±0.3 ^{ab}	4.5±0.5 ^a	74.02±1.20 ^{ab}	3.57±2.83 ^c	27.31±2.83 ^{ab}	12.14±1.61 ^e
ABT	2	13.2±0.2 ^{bcd}	3.5±0.6 ^a	77.10±1.34 ^{abc}	-0.28±3.39 ^{ab}	21.90±3.39 ^{ab}	5.85±1.36 ^{bc}
C	4	12.0±0.21 ^{ab}	4.1±0.6 ^a	76.22±0.66 ^{abc}	3.03±2.69 ^c	28.87±2.69 ^b	12.16±2.18 ^e
ABT	4	13.7±0.28 ^{cd}	3.4±0.6 ^a	77.50±0.70 ^{abc}	0.82±3.54 ^b	22.64±3.54 ^{ab}	6.02±2.34 ^{bcd}
C	7	13.00±0.17 ^{abc}	4.3±0.6 ^a	73.19±1.46 ^a	4.44±1.70 ^c	21.25±1.70 ^{ab}	9.51±0.46 ^{cde}
ABT	7	14.10±0.30 ^d	3.3±0.6 ^a	77.60±1.88 ^{abc}	0.86±2.97 ^b	21.25±2.97 ^{ab}	5.22±0.75 ^{ab}

C=untreated/netretiran, ABT=anti-browning treated/tretiran protiv posmeđivanja, SS=soluble solids/TST=topljiva suha tvar, ^ad=storage day/dan skladištenja

*p≤0.05. Results are expressed as mean±SD. Values with different letters within column are statistically different at p≤0.05./Rezultati su izraženi kao srednja vrijednost±SD. Vrijednosti s različitim slovima unutar kolone su statistički različiti pri p≤0.05.

Sensory evaluation showed remarkable differences between C and ABT samples during storage with better scored ABT samples for almost all evaluated sensory attributes (Fig. 1). The biggest changes were noticed in color, what is accordance with instrumentally measured color values. Considering taste and texture, both sample types remained pretty stable and desirable till the 4th day, after which C samples were low graded for taste (5.4), thus being hardly marketable. Furthermore, C samples were not usable at all on the 7th day, and ABT was still acceptable and marketable but with impaired sensory properties. Sensory acceptability has an extreme importance and directly affects on the consumers' desire for FC products purchase. Color has a great impact on the buying a product for the first time and also for repeat buying, and the remembrance of the texture and the taste of previously bought product is essential (Beaulieu, 2011). Since the VM is not intended for longer storage of FCFV, but only for short-termed (2-3 days), the achieved results indicate positive and successful performance of the VM prototype.

Considering microbial analysis, it especially showed that VM prototype provides a safe product through all 7 days since AMB and yeast count were under the limit according to the Regulations (Pravilnik, NN 74/08, 156/08, 89/10, 153/2011) (Fig. 2). AMB count was lower than in our previous study (Putnik et al., 2017b) in which FC apples were packaged in bags under modified atmosphere. Further, anti-browning treatment has a positive effect on reduction of AMB growth in general (Amrutha et al., 2017), and in our study AMB growth was particularly reduced in the first two days.

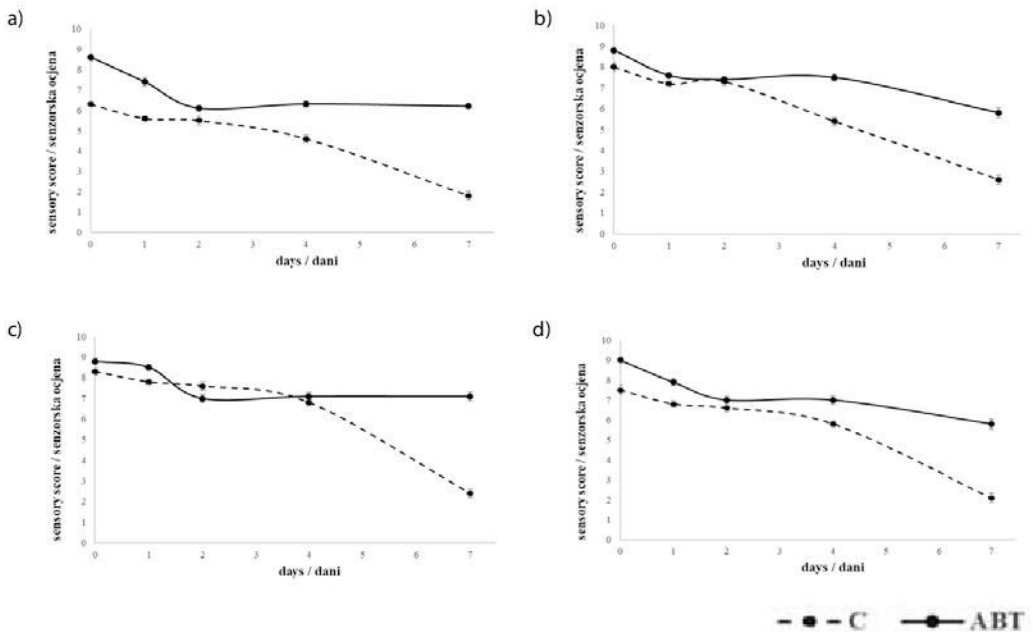


Figure 1. Color (a), taste (b), texture (c) and overall acceptability (d) of FC apples during 7 days storage

Slika 1. Boja (a), okus (b), tekstura (c) i ukupna prihvatljivost (d) FC jabuka tijekom 7 dana skladištenja

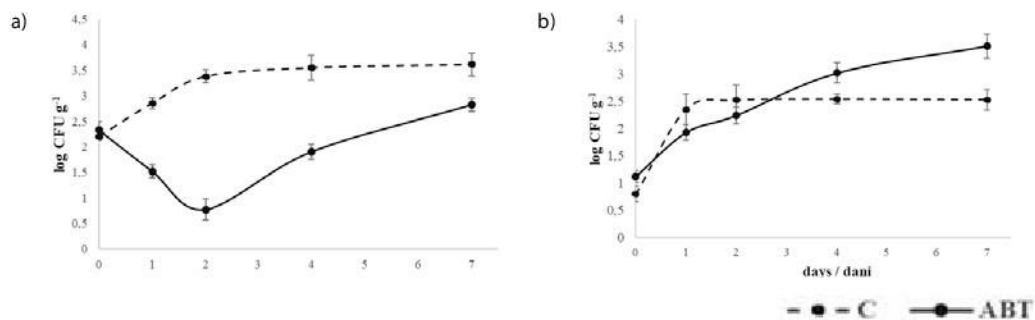


Figure 2. Microbial analysis of aerobic mesophilic bacteria (AMB) (a) and yeasts (b) of FC apples during 7 days storage

Slika 2. Mikrobiološka analiza aerobnih mezofilnih bakterija (AMB) (a) i kvasaca (b) u FC jabukama tijekom 7 dana skladištenja

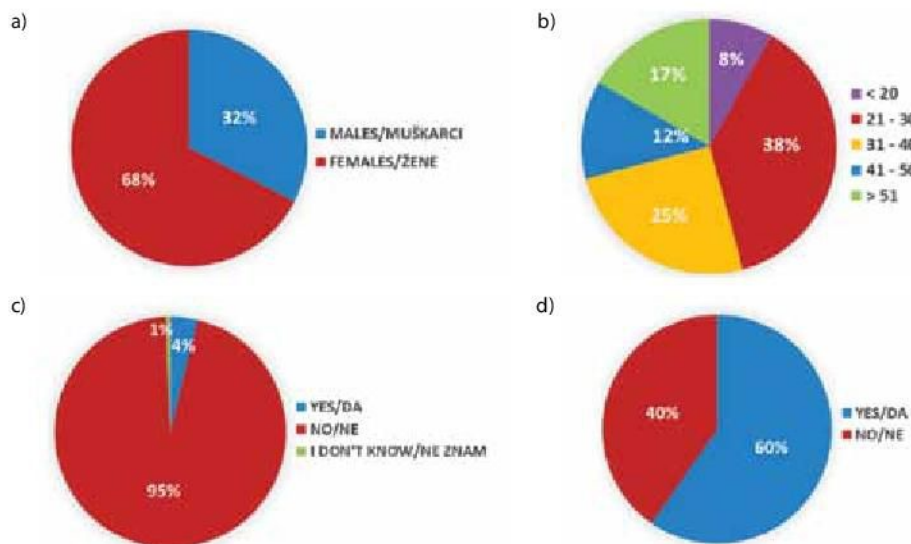


Figure 3. Gender (a) and age (b) structure of the respondents in the survey and the results regarding the questions: do you consume FV? (c) and do you buy FCFV? (d)

Slika 3. Spolna (a) i dobna (b) struktura ispitanika u anketi te rezultati ankete obzirom na pitanja: da li konzumirate voće i povrće? (c) i da li kupujete FC voće i povrće? (d)

In market analysis, most of participants were females (69%) (Fig. 3a) and most of the respondents were between 21 and 40 years (Fig. 3b). Further, 95% of them were FV consumers (Fig. 3c) and even 60% of FV consumers were usual buyers of FCFV (Fig. 3d). Beti and Cerjak (2009) examined consumers' purchasing behavior and their attitudes regarding FC lettuce in Zagreb and reported that 45% of respondents never bought FC lettuce what is similar to our findings regardless 93% respondents had an intention to buy such products in the future. But positive findings of our survey are linked with the FCFV price, where majority of respondents were ready to pay the price matched with the common market price of such product (Fig.

4a). Another promising results were regarding FCFV as a snack substitute for sweets, where approximately one third of respondents could “always” substitute sweets with FCFV, another one third “mainly” and a quarter of them “sometimes” (Fig. 4b). In support to idea about FCFV VM, 75% of FCFV buyers liked an idea to have a possibility to make their own combination of several FV types (Fig. 5a) and 81% of them liked the possibility to buy such products near the workplace (Fig. 5b). As for FCFV non-buyers, more than half of them adduced suspicion in health safety as a reason for not buying FCFV (Fig. 6a) and a high price as well (Fig 6b). In Beti and Cerjak (2009) market research respondents also adduced price as one of the limiting factors for buying FC lettuce. Although our survey was done 7 years ago and offer of FCFV has been changed in the meantime, there is still a lot of space to improve this sector.

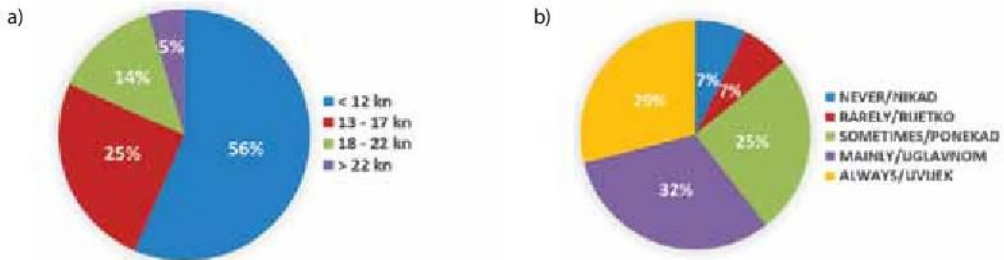


Figure 4. Survey results regarding the questions: the maximum price you would pay for FCDV? (a) and would you consume FV as a snack instead of sweets? (b)

Slika 4. Rezultati ankete obzirom na pitanja: najviša cijena koju bi platili za FC voće i povrće (a) i biste li konzumirali voće i povrće kao brzi zalogaj umjesto slatkiša? (b)

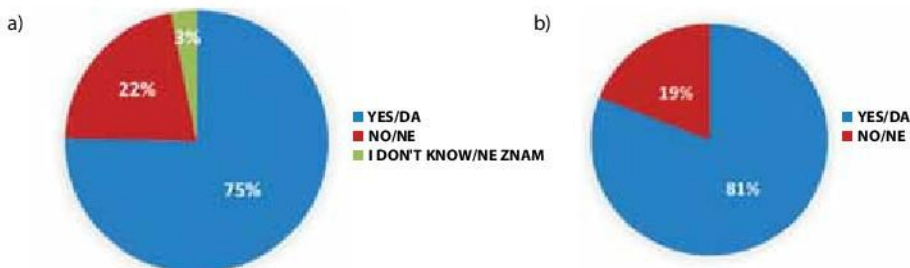


Figure 5. Circumstances that would encourage respondents who buy FCFV to more frequent purchase: the possibility of choosing the composition of such product (a) and the possibility of buying near the workplace (b)

Slika 5. Okolnosti koje bi potaknule ispitanike koji kupuju FC voće i povrće na učestaliju kupnju: mogućnost biranja sastava takvog proizvoda (a) i mogućnost kupovine u blizini radnog mjesta (b)

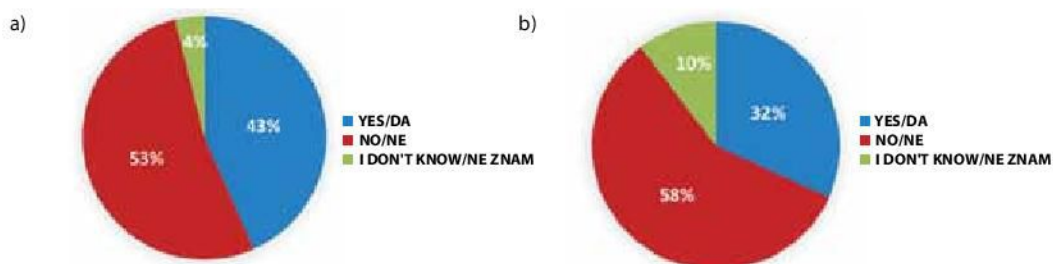


Figure 6. Reasons for not buying FCFV: suspicion in health safety (a) and excessive price (b)

Slika 6. Razlozi neкупovine FC voća i povrća: sumnja u zdravstvenu ispravnost (a) i previsoka cijena (b)

Conclusion

Since the prototype of vending machine is intended for short-term storage of fresh-cut fruits and vegetables, which usually should not be longer than 2-3 days, achieved results regarding overall quality, sensory properties and microbial quality of fresh-cut apples confirmed its usability. Further, the need for its existence on the market is supported by consumers' preference to choose their own combination of fruits or vegetables and to buy such products near the workplace. Since it was successfully tested only with apples, further investigation with other fruit and vegetable types should be performed.

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Prethodno priopćenje

Mogućnosti i perspektive svježeg narezanog voća i povrća na zagrebačkom tržištu

Sažetak

Svježe rezano (eng. fresh-cut; FC) voće ili povrće predstavlja voće ili povrće oprano, oguljeno i/ili narezano i zapakirano, u potpunosti iskoristivo, praktično te sačuvane nutritivne vrijednosti, okusa i svježine. Voće i povrće obiluje biološki aktivnim spojevima koji imaju blagotvorni učinak na zdravlje ljudi ako se konzumiraju često i svakodnevno. Zdravstveno osviješteni potrošači cijene takve proizvode zbog njihove praktičnosti iako su skloni brzom kvarenju što utječe na skraćivanje roka trajanja tih proizvoda. Optimalni uvjeti proizvodnje kao i uvjeti prodaje nužni su za održavanje njihove ispravnosti u predviđenom roku trajanja. U okviru BICRO-projekta koji se provodio na Prehrambeno-biotehnoškome fakultetu Sveučilišta u Zagrebu izrađen je prototip automata koji bi mogao zamijeniti serviranje FC voća i povrća na način tzv. salad-bara i osigurati najviše higijenske uvjete serviranja takve hrane. U prvom dijelu ovog istraživanja ispitan je rad prototipa sa svježim narezanom jabukom tijekom 7 dana, a u drugom dijelu provedena je usmena anketa građana Zagreba o njihovim navikama i interesu vezano za FC voće i povrće. Kvaliteta i senzorske osobine FC jabuka skladištenih u prototipu bile su zadovoljavajuće 4 dana, a mikrobiološka analiza pokazala je da prototip daje siguran proizvod kroz 7 dana. Temeljem odgovora građana koji su iskazali interes da prilikom kupovine FC voća i povrća sami biraju vlastitu kombinaciju te da im je moguće kupovati takve proizvode i blizu radnog mjesta, čini se da postoji potreba za postojanjem ovakvog automata. Općenito, analiza tržišta ukazala je da građani kupuju FC proizvode i da postoji interes za proširenjem ponude.

Ključne riječi: fresh-cut voće i povrće, fresh-cut jabuka, automat, mikrobiološka analiza, analiza tržišta