Универзитет у Београду
Институт за мултидисциплинарна истраживања
Кнеза Вишеслава 1а
11030 Београд

Научном већу

Поштовани,

обраћам вам се поводом техничког решења "Слани кекс са дехидрираним целером" аутори су др Јелена Филиповић, *научни саветник,* др Миленко Кошутић, *виши научни сарадник,* др Владимир Филиповић, *научни саветник,* др Милица Нићетин, *виши научни сарадник,* др Ивица Ђаловић, *научни саветник,* др Горан Триван, *научни сарадник,* др Драгица Станковић, *научни саветник,* са молбом да донесете Одлуку о усвајању предметног техничког решења, као и да донета одлука са пратећом документацијом буде прослеђена Матичном научном одбору за биотехнологију и пољопривреду Министрства науке, технолошког развоја и иновација.

У Београду, 23.01.2025.године

др Горан Триван
научни сарадник

Техничко решење

СЛАНИ КЕКЕКС СА ДЕХИДРИРАНИМ ЦЕЛЕРОМ

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НАЗИВ ТЕХНИЧКОГ РЕШЕЊА:	Слани кекс са дехидрираним целером
КЉУЧНЕ РЕЧИ:	Комбинована метода дехидратације, кекс, целер, технолошки квалитет, нутритивни састав
ВРСТА ТЕХНИЧКОГ РЕШЕЊА:	Ново техничко решење примењено на међународном нивоу (М81=10)
ЗА КОГА ЈЕ ТЕХНИЧКО РЕШЕЊЕ РАЂЕНО:	КОРНИ д.о.о Београдска 39, 85 000 Бар, Црна Гора
ГОДИНА КАДА ЈЕ ТЕХНИЧКО РЕШЕЊЕ КОМПЛЕТИРАНО :	2024. год.
ГОДИНА КАДА ЈЕ ПОЧЕЛО ТЕХНИЧКО РЕШЕЊЕ ДА СЕ ПРИМЕЊУЈЕ И КО ЈЕ ТЕХНИЧКО РЕШЕЊЕ ПРИХВАТИО :	2024. год. КОРНИ д.о.о Београдска 39, 85 000 Бар, Црна Гора
КАРАКТЕР ТЕХНИЧКОГ РЕШЕЊА:	Нов прехрамбени производ
ОБЛАСТ И НАУЧНА ДИСЦИПЛИНА:	Биотехничке науке и прехрамбено инжењерство
ПРОБЛЕМ КОЈИ СЕ ТЕХНИЧКИМ РЕШЕЊЕМ РЕШАВА:	Нов производ решава проблем унапређења процеса сушења домаћег целера при чему се добија нутритивно и сензорно обогаћен прах, који је, као природни и функционални састојак, иновативна замена за део брашна при стандардном технолошком процесу производње кекса.

СТАЊЕ РЕШЕНОСТИ ТОГ ПРОБЛЕМА У СВЕТУ	Целер дехидриран предложеним комбинованим методима осмотске дехидратације у меласи и лиофилизације, до сада се није додавао у слани кекс. Примењена технолошка решења су у складу са препорукама здраствених студија о бенефиту конзумирања поврћа, његовом обогаћивању и праћењу савреминих трендова прехрамбене индустрије у погледу одрживости и економичности процеса производње.
КАКО СУ РЕЗУЛТАТИ ВЕРИФИКОВАНИ:	Научни пројекат у оквиру кога је развијена нова врста производа: „Слани кекс са дехидрираним целером“, финасиран је од стране Покраинског секретаријата за високо образовање и научноистраживачку делатност АПВ, број уговора: 000882147 2024 09418 003 000 000 001 04 002. Резултати техничког решења су верификовани и саопштени на међународним скуповима (2 ком.) и у часопису (1 ком.).
ПРОИЗВОЂАЧ ОПРЕМЕ И АДРЕСА:	Esmach
АДРЕСА:	Via Vittorio Veneto, 143, Италија
КОРИСНИК ТЕХНИЧКОГ РЕШЕЊА И АДРЕСА :	КОРНИ д.о.о Београдска 39, 85 000 Бар, Црна Гора
ГОДИНА ОСНИВАЊА ФИРМЕ:	1990. год.
ОПИС ТЕХНИЧКОГ РЕШЕЊА:	Ово техничко решење показује могућност употребе праха целера добијеног комбинованим методама сушења, као супституента пшеничног брашна у формулацији кекса. Нов производ кекса има значајно побољшану нутритивни и функционални састав, уз смањење енергетске вредности.

ПРИМЕНА ТЕХНИЧКОГ РЕШЕЊА:	Новоразвијени слани кекс може се производити у постојећим погонима прехрамбене индустрије, без посебних инвестиционих улагања и потребе за модификацију технолошког поступака производње и конфигурације погона. Овај нови кекс доприноси проширењу асортимана постојећих брашнено-кондиторских производа, нудећи унапређену и квалитетнију алтернативу. Дистрибуција новог кекса може се остварити кроз постојеће трговинске мреже, ка свим прехрамбеним и специјализованим продавницама здраве хране, чиме би овај производ постао приступачан потрошачима региона.
ОДГОВОРНО ЛИЦЕ ЗА ТЕХНИЧКО РЕШЕЊЕ:	Др Јелена Филиповић, *научни саветник*
ОДГОВОРНО ЛИЦЕ КОРИСНИКА ТЕНХИЧКОГ РЕШЕЊА:	Стеван Главичић, дипл. инж.

УНИВЕРЗИТЕТ У НОВОМ САДУ

НАУЧНИ ИНСТИТУТ ЗА ПРЕХРАМБЕНЕ ТЕХНОЛОГИЈЕ
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Опис техничког решења

Аутори техничког решења:

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- Др Горан Триван, *научни сарадник*
- Др Драгица Станковић, *научни саветник*

СЛАНИ КЕКЕКС СА ДЕХИДРИРАНИМ ЦЕЛЕРОМ

Нови Сад, 2024

1. **Област технике на коју се техничко решење односи**

Техничко решење "Слани кекс са дехидрираним целером" се односи на област прехрамбене индустрије, односно брашнено кондиторску индустрију. Кекс је популаран производ широм света, постоји велика понуда слатких и сланих кексова са различитим укусима и приступачним ценама. Овај производа је одмах спреман за јело са дугим роком трајања, што га чини веома популарним прехрамбеним производом (Calanlis et al., 2020).

Кекс је сложен систем у коме сваки састојак има важну улогу, а свака промена у формулацији кекса обично доводи до промена у тесту, које утичу на квалитет готовог производа. За форморање структуре кекса непожељан је развој глутенске структуре брашна, јер тесто ове врсте кекса карактерише недовољна растегљивост и еластичност. Кекс карактерише висок садржај масти и шећера, а мала количина воде што му обезбеђује пластичност, односно мању еластичност, при чему битну улогу имају шећери и масти у тесту. Шећер битно утиче на особине теста као и на квалитет и укус печеног производа. Шећер доприноси смањењу вискозитета и времену одмарања теста, а истовремено доводи и до ширења кекса и смањења његове висине и масе. Кекс са високим садржајем шећера карактерише високо кохезивно тесто и хрскава текстура. Маст у тесту делује као мазиво при чему доприноси пластичности и омекшавању теста. Маст утиче на текстуру и укус, а доприноси повећању дужине и смањењу висине и масе кекса, кога карактерише мека структура и лака ломљивост (Calanlis et al., 2018).

Третман сушењем (дехидратацијом) воћа и поврћа једна је од најчешћих технологија обраде и чувања хране. Класичне методе сушења се заснивају на високим температурама и дугом времену сушења што доводи до оштећења неких нутритијената и квалитетних својстава у производу (Lyu et al., 2019). У циљу решавања ових проблема, користе се комбиноване методе дехидратације.

Конвективно сушење једна од најчешће коришћених метода за дехидрацију воћа и поврћа, али има своје недостатке узроковане применом високих температура, које утичу на губитак боје, погоршање текстуре, промену укуса и губитак важних нутритивних материја (Kręcisz et al., 2023). Супротно томе, метода лиофилизације пружа велики потенцијал за очување нутритивног и сензорног квалитета дехидрираних производа, али истовремено утиче на повећање трошкова и времена извођења процеса (Marić et al., 2020, Ignaczak et al., 2023).

Коришћена комбинована метода дехидратације обухвата нискоенергетски осмотски предтретман у меласи и скраћени поступак захтевне, високоенергетске лиофилизације. Дехидрирана сировина обогаћена је нутритивним материјама из меласе, а добија се на економичан и енергетски ефикасан начин (Filipović et al., 2022).

Процес осмотске дехидратације подразумева потапање прехрамбеног материјала у хипертоничне растворе, где вода дифундује из хране ка раствору кроз полупропустљиве мебране ћелијског ткива хране, док у супротном смеру, растоврак који се налази у осмотском раствору, дифундује у мањем обиму ка прехрамбеном материјалу. Меласа шећерне репе се показала као добар избор за осмотски раствор, услед високе технолошке ефикасности феномена преноса масе, високо вредног нутритивног састава и ниске цене, обзиром да је нуспроизвод технологије производње шећера (Filipović et al., 2017; Nićetin et al., 2021). Осмотска дехидратација се обично користи као предтретман осталим процесима дехидратације, као што је на пример лиофилизација.

2. Технички проблем

Производи од жита су свакодневни састојци свих режима исхране, стога одлична врста производа за побољшање нутритивних и функционалних особина, у складу са савременим трендовима у исхрани.
Применом метода комбиноване дехидратације, која се састоји од енергетски незахтеване осмотске дехидратације у меласи и сукцесивног скраћеног високоенергетског поступака лиофилизације, истовремено се решавају проблеми искоришћавања и поновне употребе меласа - споредног производа идустрије шећера и скраћивање обима примене високо енергетски захтевног поступка лиофилизације. Дехидрирани производ, који се добија као резултат примене методе комбиноване дехидратације, је врхунског квалитета, обзиром на очуване, полазне термостабилне компоненте, додатно унапређене повољним нутритивним саставом меласе.
Додатком дехидрираног целера комбинованом методом дехидратације у кекс, добија се производ унапређених квалитативних карактеристика у погледу нутритивних и функционалних особина, доброг технолошког и сезорског квалтета. Кекс је производ који се скоро свакодневно конзумира у различитим облицима и доступан је великој популацији. Из тог разлога је оправдана могућност апликације дехидрираног целера како би се смањила енергетска вредност, повећао садржај минералних материја и антиоксидативни потенцијал, што се рефлектује на одржање и побољшање здравља људи.

3.Стање решености тог проблема у свету

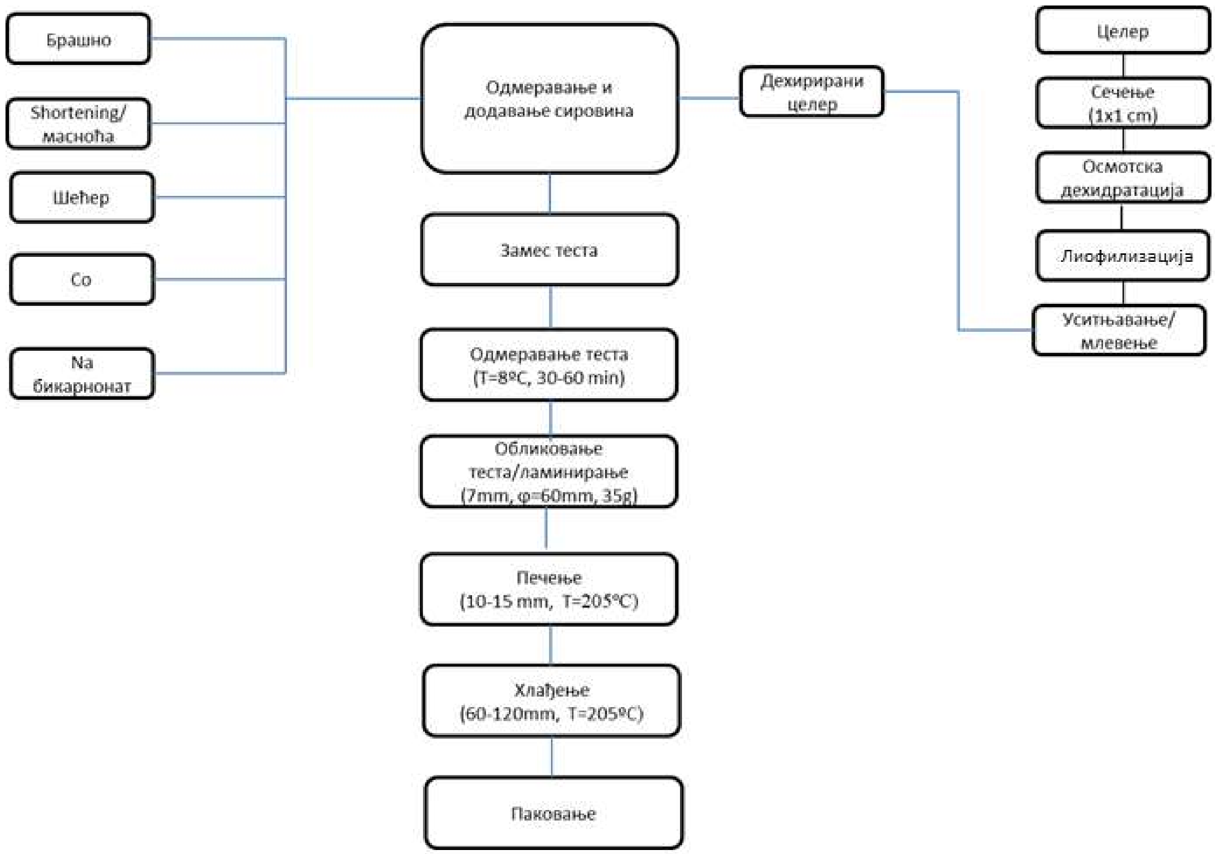
Производи од жита обезбеђују неопходне хранљиве материје и енергију и представљају основну храну различитих популација широм света (Shahidi, Chandrasekara, 2015). Жита се гаје на више од 73% пољопривредног земљишта и чине више од 60% производње хране у свету. Хранљиву вредност жита доминанто чине угљени хидрати, знатно мање је осталих хранљивих материја (протеина, масти, минерала и витамина).
Данас, постоји тренд раста потрошње прехрамбених производа побољшане нутритивне вредности и улажу се напори да се она промени преко модификације нутритивног састава. Претварање споредних производа који настају у току производње хране у високо вредне компоненте и додатке за прехрамбене производе, изазива велико интересовање прехрамбене индустрије поготово јер потрошачи преферирају природне додатке, плашећи се да синтетички састојци могу бити извор токсичности (Elleuch et al., 2011).
У циљу побољшања здравља људи и пораста свести поторшача о повезаности исхране и здраственог стања постоји потреба за променом у саставу кекса како би се побољшали његов нутритивни састав и функционална својства. Студије о исхрани препоручују редовно

конзумирање воћа и повра у циљу побољшања здравља (Calanlis et al., 2020). Епидемиолошке студије су показале да конзумирање поврћа, воћа и деривата прехрамбених производи има здравствене предности у превенцији хроничних незаразних болести, укључујући кардиоваскуларне болести и одређене врсте канцера. Здравствена својства воћа и поврћа се приписују присуством витамина, прехрамбених влакана и полифенола.

4. Стање технике

Осмотска дехидратација у индустријским условима се изводи растворима натријум хлорида или сахарозе, у зависности од сировине која се дехидрира. У овом техничком решењу као осмотски раствор коришћена је меласа шећерне репе која представља споредни производ у индустрији шећера, а карактерише га ниска цена, добр нутритивни састав, а сам процес је економичан због искоришњења споредног производа прехрамбене индустрије.
Комбиновано сушење се састоји од енергетски незахтевне осмотске дехидратација као предтретмана и скраћеног поступка лиофилизације при чему се добија високо вредан дехидриран производ унапређених нутритивних карактеристика (Filipović et al., 2022).
Процес припреме комбинованог сушења рађен је у погону „ESSALK d.o.o.“ Трнава бб, Нови Пазар, на постојећој опреми за осмотску дехидратацију и лиофилизацију. Технолошки параметри комбинованог процеса осмотске дехидратације у меласи и лиофилизаци целера урађени су у лабораторијским условима Технолошког факутета Нови Сад, Универзитета у Новом Саду.
Овај нови кекс се може производити у свим погонима прехрамбене индустрије, јер не захтева додатне инвестиције и технолошке модификације производног поступка и погона. Једино у фази припреме сировина поред одмеравања сировина за замес, постоји још једно одмераравање дехидрираног целера у одређеној количини (слика 1). Технолошки поступак производње се састојао од следећих фаза (слика 1):

- одмеравања сировина,
- замеса теста,
- обраде теста,
- печења теста,
- и на крају хлађења готовог производа.



Слика 1. Технолошки поступак производње обгаћеног сланог кекса са дехидрираним целером

5. Излагање суштине техничког решења

Применом комбиноване методе дехидратације целера која се сатоји од осмотске дехидратације у меласи као предтретмана и скраћене високоенергетске лиофилизације добија се прах целера очуваних и обогаћних нутритивних и фукционалних компонента. Додавањем 20% дехидрираног праха целера добијеног комбинованим методама дехидратације у стандардну рецептуру сланог кекса добија се нов иновативни производ са побољшаним нутитивним у функционалним каратктеристикама, а меласа шећрене репе као споредни производ у технолошком поступку производње шећера се враћа у ланац исхране људи и добија нову употребну вредност.

6. Детаљан опис техничког решења

6.1. Нутритивни састав дехидридраног целера

Свеж корен целера (*Apium graveolens L. var. rapaceum, Alabaster variety*) има просечни садржај суве материје: 9,05%. За потребе анализе хемијског и минералног састава корена целера дехидрираног комбинованим методама, у табелама 1. и 2., приказани су резултати нутритивног састава целера дехидрираног различитим методама: конвектиним сушењем, лиофилизацијом и комбинованом методом (осмотска дехидратација и лиофилизација). Из приказаних резултата у табели 1., види се да целер сушен комбинованом метором (О.Д.+Л.Ц.) има статистички значјано већи садржај протеина, укупних шећера и пепела, а мањи садржај целулозе и липида у поређењу са узорцима целера сушених конвектимном методом (Ков. Д.Ц.) и лиолифилизациом (Лио.Д.Ц).

Табела 1. Хемијски састав дехидрираног целера (Košutić et al., 2024)

Узорци	Протеини (% с.м.)	Скроб (% с.м.)	Ук. шећери (% с.м.)	Целулоза (% с.м.)	Липиди (% с.м.)	Пепео (% с.м.)
Ков.Д.Ц.*	1.04 ± 0.04^{a}	0.85 ± 0.08^{a}	5.25 ± 0.15^{a}	2.64 ± 0.09^{b}	0.30 ± 0.01^{a}	0.81 ± 0.03^{a}
Лио.Д.Ц.**	1.31 ± 0.05^{b}	1.01 ± 0.05^{b}	5.31 ± 0.09^{a}	2.71 ± 0.05^{b}	0.30 ± 0.01^{a}	0.79 ± 0.02^{a}
О.Д.+Л.Ц. ***	4.36 ± 0.19^{c}	1.04 ± 0.03^{b}	24.99 ± 0.99^{b}	1.57 ± 0.04^{a}	0.26 ± 0.00^{a}	4.97 ± 0.49^{b}

* Конвективно дехидрирани целер

** Лиофилизирани дехидрирани целер

*** Осмотски дехидрирани и лиофилизирани целер

Резултати приказују средњу вредност±стандардну девијацију у три мерења

$^{a-c}$ Različita slova u eksponentu u istim kolonama ukazuju na statistički značajne razlike pri nivou značajnosti od od $p<0,05$ (testiran post hoc Tukey HSD test)

Минерални састав целера дехидрираног различитим методама је приказан у табели 2. Целер дехидриран комбинованом методом (О.Д.+Л.Ц.) има статистички значајно већи минерални сатсав у погледу K, Mg, Ca, Fe, Zn и Cu у односу на целер дехидридран конвективном методом и лиофилизацијом, као последица прираста суве материје, из минералим материјама богатом меласом, у процесу осмотске дехидратације.

Табела 2. Минерални састав дехидрираног целета (Košutić et al., 2024)

Узорци	K (mg/100g с.м.)	Mg (mg/100g с.м.)	Ca (mg/100g с.м.)	Fe (mg/100g с.м.)	Zn (mg/100g с.м.)	Cu (mg/100g с.м.)
Ков.Д.Ц.*	308.43 ± 0.94[a]	23.13 ± 0.11[a]	73.08 ± 0.21[a]	0.78 ± 0.03[a]	0.71 ± 0.02[a]	0.51 ± 0.02[a]
Лио.Д.Ц.**	309.75 ± 1.05[a]	23.94 ± 0.24[a]	73.94 ± 0.34[a]	0.79 ± 0.02[a]	0.74 ± 0.04[ab]	0.52 ± 0.00[a]
О.Д.+Л.Ц.***	1825.74 ± 20.16[b]	42.74 ± 1.75[b]	120.49 ± 1.55[b]	5.39 ± 0.75[b]	1.35 ± 0.15[b]	0.84 ± 0.03[b]

* Конвективно дехидрирани целер
** Лиофилизирани дехидрирани целер
*** Осмотски дехидрирани и лиофилизирани целер
Резултати приказујеу средњу вреднос ±стандардну девијацију у три мерења
a-c Различита слова у експоненту у истим колонама указују на статистички значајне разлике при нивоу значајности од od $p<0,05$ (тестиран post hoc Tukey HSD test)

За производњу сланог кесаса са дехидрираним целером коришћен је целер дехидриран комобинованом методм (О.Д.+Л.Ц.) услед најбољег хемијског (табела 1) и минералног (табела 2) састава у односу на целрер дехидриран конвективном и лиофилизованом методом.

6.2. Технолошки поступак добијања дехидридраног целера

Технолошки поступак дехидрирања целера комбинованом методом састоји се од осмотског предтретмана у меласи шећерне репе, а затим сукцесивне лиофилизације. Процес дехидратације целар се изводи у „ESSALK д.о.о. " Трнава бб, Нови Пазар.

Процес почиње допремањем свежег целера у производни погон, где се чува у расхладним уређајима за складиштење, на температури од 4 °C. Након складиштења целер се љушти, пере и уситњава. Осмотски третман целера се изводи на постојећој опреми за осмотску дехидратацију, у меласи шећерне репе, као хипертоничном раствору. Технолошки параметри процеса осмотске дехидратације целера у меласи утврђен је у лабораторијским условима и износили су:

- Дужина трајања процеса: 5h,
- Температура процеса: 20 °C,
- Масени однос материјала и осмотског раствора (меласе): 1:5,
- Концентрација осмотског раствора: концентрована меласа: 85,04%.

Након осмотског третмана, дехидрирани целер се чува у расхладним коморама на температури од -30°C, 24 сата. Замрзнути целер се дехидрира помоћу погонског лиофилизатора.

Процес лиофилизације траје 24 сата на притисаку од 1.6 Pa и температури кондензатора -57 °C.

Дехидрирани целер се уситњава на млину до добијања праха уједначене гранулације.

Овако добијен дехидрирани прах целер има обогаћен нутритивни садржај (табела 1 и 2), без влаге, што обезбеђује дуготрајно складиштење и доступност као сировине за пекарску и кондиторску индустрију.

6.3 Технолошки поступак производње и технолошки квалитет кекса са дехидрираним целером

На тржишту региона нема овакве врсте производа - сланог кекса са заменом дела брашна дехидрираним и обогаћеним целером. При производњи овог новог производа битно је да се не наруши технолошки квалитет и сензорска својства производа, а да се побољша нутритивни и функционални састав. Обгаћени слани кекекс са дехидрираним целером се производи по стандарданом технолошком поступку у индустријским условима КОРНИ д.о.о, у Бару, у Црној Гори. Тесто за слани кекс се припрема на основу сировинског састава који је приказан у табели 3, а количина додате воде прерачуната је како би се добило тесто влаге 18%.

Табела 3. Сировински састав теста за производњу кекаса са дехидрираним целером

	Контролни узорак	Кекс са 20% О.Д+Л.Ц.
Брашно (%)	100	80
Дехидрирани целер (%)	0	20
	База за обрачун: маса брашна	
Shortening/маргарин (%)	28,5	28,5
Шећер (%)	1	1
NaCl (%)	0,9	0,9
$NaHCO_3$ (%)	1	1
Вода (%)	22	22

6.4 Технолошки квалитет кекса са дехидрираним целером

Замена брашна било којом компнентом у основној формулацији кекса може довести до промене у физичко-хемијским својствима пре свега параметра који дефинишу технолошки квалитет, као што су димензије кекса и текстура (Klunklin et al., 2018). Приликом механичког мешања, сировина које се користе у саставу кекса долази до њихове интеракције како би се формиро јединствен облик, конзистенција и изглед, а боја и укус у последњој фази печења (Galla et al., 2017). Утицај замене дела брашна са дехидрираним целером у количини од 20% на технолошке параметре квалитета кекса приказан је у табели 4.

Табела 4. Технолошки пареметри кекса са дехидрираним целером (Nićetin et al., 2024)

	Контролни узорак	Кекс са 20% О.Д+Л.Ц.
Технолошки параметри		
BWL (%)	25,22±0,51	17,00±0,46
DWL (%)	0,96±0,13	0,65±0,04
T (mm)	55,05±0,81	48,42±0,49
R (mm)	97,05±0,83	99,73±0,38
R/T	1,76±0,01	2,06±0,01
Текстура кекса		
Tvr (N)	2091,73±193,53	3923,50±300,59,
Lom (mm)	1,30±0,20	2,49±0,1

BWL- губитак масе при печењу, DWL –губитак масе при сушењу , T – висина кекса, R –просечан пречник, R/T – фактрор ширења, Tvr- тврдоћа, Lom- ломљивост
Резултати приказују средњу вредност ± стандардну девијацију три мерења

Технолошки параметри квалитета кекса су одређени по методи AACC 10-50D (1999), 30 минута након хлађења кекса, а обухватала су мерење димензија кекса и губитка масе кекса при печењу и сушењу. Губитак масе при печењу (BWL) и губитак масе при сушењу (DWL) су битни параметри технолошког квалитета јер указују на текстуру и принос готовог производа. Додавањем 20% дехидрираног целера у рецептуру кекса доводи до стстистички значајног смањена параметара губитака масе при печењу (BWL) и при сушењу (DWL) у односу на контролни узорак. Ово се може објаснити чињеницом да дехидрирани прах целера је високо целулозни материјал у поређењу са адекватном количином брашна која је оскудна у нерастворљивим прехрамбеним влакнима, при чему доводи веће апсорпције воде и слабљења протеинске мреже (Wang et al., 2020). Целулозна влакна могу да апсорбују одређену количину воде и вероватно на тај начин утичу на бољу дистрибуцију влаге у тесту, па се током печења када се температура повећа, вода јаче везује и мање воде испарава (Salehi et al., 2020). Фактори који описују димензије кекса (висина, просечан пречник и фактор ширења) су важни за дефинисање утицаја додатка на његове технолошке карактеристике и у контроли квалитета готовог производа. Висина кекса је последица формирања структуре теста током печења кроз постављање равнотеже између коагулације протеина и ширења теста, услед стварања паре и ослобађања гаса из средстава за дизање (Mamat et al., 2010). Додавање дехидрираног целера довело је до дестабилизације структуре теста, што је довело до смањења висине кекса у односу на контролни узорак што је у складу са истарживачима Wang et al., (2020). Из табеле 4, се види да одавање дехидрираног целера у кекс, пречник кекса и фактора ширења (R/T) значајно повећо у односу на контролни узорак, односно дошло је до повећања деформаце облика кекса услед додатка дехидрираног целера. Комбинација истих фактора током формирања теста и печења кекса утичу на висину, просечан пречин и фактор ширења кекса.

Тексрура кекса је одрђена на апарату TA.XT2 Texture Analyser (Stable Micro Systems, Godalming, UK), где су дефинисани тврдоћа (Tvr) и ломљивост (Lom) који су кључних параметара на основу којих потрошачи процењују квалитет кекса. Тврдоћа се дефинше силом која је потребна да изазове потпуни прелом кекса, док је ломљивост показатељ крхкости текстуре и њене склоности да се мрви (Galla et al., 2017). Из табеле 4 се види да се тврдоћа кекса значајно повећава са додатком дехидрианог целера у односу на контролни узорак. Ово се објашњава чињеницом да додатком садржаја влакана у кекс они механички ометају интеракцију протеина и способности формирања протеинског матрикса. Такође, влакна апсорбују воду тако да количина воде која је доступна за хидратацију и развој протеинског матрикса се смањује, што доводи до разблажења концентрације протеина, што има за последицу већу тврдоћу кекса (Galla et al., 2017, Sowmya et al., 2022). Такође се запажа исти тренд за параметар ломљљивости као и за чврстоћу кекса, да долази до значајног повећања ломљивости са додатком дехидрираног целера. Ломљивост кекса се повећава са повећањем садржаја влакана укључивањем неглутенских сировина (целера и меласе) у формулацију кекса, који ометати формирање протеинског матрикса, по истом механизму као и код тврође (Sowmya et al., 2022).

Боја је битан параметар квалитета производа која директно утиче на перцепцију и прихватљивост производа од стране потрошача. Боја кекса је одређена на тристимулусном колориметру Chroma meter (CR-400, Konica, Minolta, Japan) и израчуната у CIELAB систему.

Табела 5. Боја кекса са дехидрираним целером (Nićetin et al., 2024)

	Контролни узорак	Кекс са 20% О.Д+Л.Ц.
L*	57,79±1,01	47,98±0,37
a*	6,55±0,13	8,99±0,57
b*	22,72±0,29	14,83±0,30
ΔE	0	17,84±0,65

L – светлоћа (0 црно, 100 бело), a – удео зелено (-)/црвеног (+) тона, b- удео плаво (-)/жутог (+) тона, ΔE – варијација у боји

Резултати су приказани као просечна вредност ± стандардна девијација од шест понављања.

Резултати (табела 5) показују да додатак 20% дехидрираног целера у кексу доприноси значајном смањењу светлоће (L*) и удела жутог тона (b*) и повећању удела црвеног тона (a*). На основу смањења параметра L и b* може се видети да додатак дехидрираног целера доводи до тамњења готовог производа, а повећање удела црвеног тона који потиче од комбиноване методе дехидратације целера, где се као медијум користи меласа. На основу израчунате вредности варијације у боји (ΔE) јасно се види да додатак дехидрираног целера у кексу утиче на промену боје која је видљива голим оком (Nićetin et al., 2024).

Сензорска оцена квалитета производа је битна приликом формирања новог производа и његовог пласирања на тржишту, јер смањује ризик од неуспеха у погледу потрошачке прихватљивости и дефинише границе у којим је могуће додати додатак у производ а да утоме многоме не наруши квалитет и прихватљивост код потрошача (Milićević, 2018). Сензорска оцена кекса са дехидрираним целером спроведена је по ISO 6658:2017, а за процену сензорских карактеристика примењена је скала у 7 нивоа (1 је означен као најлошији а 7 је означен као најбоља оцена).

Табела 6. Сензорска оцена кекса са дехидрираним целером (Nićetin et al., 2024)

	Контролни узорак	Кекс са 20% О.Д+Л.Ц.
Интензитет боје	3,5±0,2	5,6±0,2
Изглед површине	5,9±0, 3	3,5±0,4
Укус	4,0±0,1	3,3±0,5
Мирис	4,0±0,1	3,3±0,4
Тврдоћа	3,0±0,2	5,0±0,5
Ломљивост	4,0±0,0	6,1±0,1

Резултати су приказани као просечна вредност ± стандардна девијација од десет понављања.

На основу сензоске анализе кекса са дехидрираним целером (табела 6) види се да је интензитет боје пратио тренд инструменталног мерења боје израженог преко параметра L*, односно да додатак дехидрираног целера значајно повећва интензитет боје кекса. Интензитет боје кекса без додатка, оцењен је оценом 3,5 између светло румене и оптималне боје, док додатак дехидрираног целера значајно је повећао боју од оптималне до мало тамне. Изглед површине контролног кекса оцењен је скоро највишом оценом (оцена 5,9) док се погоршао додатком дехидрираног целера (оцена 3,5) (Nićetin et al., 2024).

Резултати анализе укуса и мириса кекса су показали сличан тренд, односно да је додатак дехидрираног целра у слани кекса утицао на смањивање дескрипотора за скоро једну оцену. Укус и мирис кекса са дехидрираним целером се од отималног померио ка оцени "мало изражен стран укус и мирис“ (Nićetin et al., 2024).

Тврдоћа и ломљивост у кексу са дехидрираним целером је повећана у односу на контролни узорак. Тврдоћа се од мало тврде (оцена 3) код контролног узорка померила до средње тврде (оцена 5,0), што је у корелацији и са инструменталним методима одређеним за тврдоћу кекса (табела 4), а ломљивост се од оптималне (оцена 4) се померила ка средње ломљивом (оцена 6,1).

6.5 Нутритивне и функционалне особине кекса са дехидрираним целером

Кекс је комплексан више компонетни систем који се састоји од макромолекула, као што су протеини, угљени хидрати, липиди и додаци. Слани кекс карактерише низак садржај протеина и висок садржај масти. Додатак дехидрираног целера кексу, у количини од 20% замене брашна, доводи до значајног смањења садржаја протеина, скроба и липида и повећања укупних шећера, целулозе и пепела у поређењу са контролним узорком (табела 7). Промене у хемиском саставу кекса са дехидрианим целером последица су уграђивања нескробних и нелипидних једињења које улазе у сировински састав кекса. Ови резултати указују да додатак 20% дехидрираног целера доводи до значајних промена у хемијском саставу сланог кекса и значајног смањења енергетске вредности, за око 20%, због додатка дехидрираног целера.

Табела 7. Нутритивни састав кекса са дехидрираним целером (Nićetin et al., 2024)

	Контролни	Кекс са 20% О.Д+Л.Ц.
Хемиски састав		
Протеини (% s.m)	10,85±0,10	9,67±0,07
Скроб (% s.m)	47,33±0,27	38,06±0,39
Ук. шећери (% s.m)	2,17±0,03	6,84±0,04
Целулоза (% s.m)	0,32±0,01	0,59±0,01
Липиди (% s.m)	23,07±0,19	18,43±0,21
Пепео (% s.m)	0,41±0,00	1,35±0,01
Енергетска вредност (kJ/g)	2018,1±157,4	1614,3±97,8
Минерални састав		
K (mg/100g s.m)	90,63±0,57	438,46±3,14
Mg (mg/100g s.m)	16,79±0,15	21,99±0,13
Ca (mg/100g s.m)	24,54±0,19	43,60±0,26
Fe (mg/100g s.m)	1,20±0,01	2,11±0,02
Zn (mg/100g s.m)	0,39±0,00	0,59±0,00
Cu (mg/100g s.m)	0,24±0,00	0,36±0,00

Резултати су приказани као просечна вредност ± стандардна девијација од десет понављања.

Дневне потребе у минералним материјама су мале али неопходне за нормално функционисање организма и из тог разлога је пожељно обогатити кекс овим једињењима. Резултати су показали да додатак 20% дехидрираног целера доводи до значајног повећања у садржају K, Mg, Ca, Fe и Zn у одоносу на контролни узорак кекса (табела 7). Ови подаци указују да употребом комбиноване методе дехидратације и меласе која се користи као медијум за осмотску дехидратацију, а богата је минералним материјама, доприноси се побољшању минералног састава кекса. Кекс са додатком 20% дехидрираног целера доприноси задовољавању дневних потреба човека у минералним материјама за нормално функционисање организма.

У циљу дефинисања функционалних својстава кекса са дехидринаим целером одређена је антиоксидативна активност. Већина антиоксидативног потенцијала у храни биљног порекла потиче од особине фенолних једињења, која могу да делују као редукциона средства, чистачи слободних радикала и донори водоника (Galanakis, 2012).

Укупни садржај фенола и антиоксидативна активност утврђени двема различитим методама (DPPH и ABTS) у узорцима кекса. Из табеле 8, се види да додатак 20% дехидрираног целера занчајно је повећао садржај укупних фенола и антиоксидативну активност (DPPH и ABTS) у односу на контролни узорак кекса. Ови резултати указују да додавање дехирираног целера, дехидрираног комбинованом методом је ефикасан начин да се сачува антиоксидативни потенцијал додатка и побољша антиоксидативна активност кекса. Садржај укупних фенола у кексу са 20% дехирираног целера повећао се 29,5 пута у односу на контролни узорак. Ово се може се приписати синергистичком доприносу очувања садржаја фенолних једињења целера и осмотској дехидратацији у меласи, поступку који је додатно обогатио дехидрирани целер са фенолним једињењима из меласе. Антиоксидативни потенцијал одређен DPPH и ABTS методама, повећан је код кекса са дехидрираним целером од 56,6 до 49,3 пута у односу на контролни узора. Ови резултати показују да додавањем материјала богатиих фенолима и другим биоактивним једињењима доводи до побољшања антиоксидативних својстава прехрамбеног производа (Deepali et al., 2019).

Табела 8. Функционалне особине кекса са дехидрираним целером (Nićetin et al., 2024)

	Контролни узорак	Кекс са 20% О.Д+Л.Ц.
Укупни фенолии (mg GAE/100g s.m)	6,42±0,04	189,41±2,54
Антиоксидативна активност DPPH (μmol TE/100g s.m)	0,60±0,00	33,97±0,57
Антиоксидативна активност ABTS (μmol TE/100g s.m)	2,43±0,02	119,71±1,02

Резултати су приказани као просечна вредност ± стандардна девијација од десет понављања.

6.6 Прихватљивост кекса са дехидрираним целером на тржишту

Разумевање мотива који одређују избор хране веома је важан за успешно промовисање иновативног производа, што је од суштинског значаја за развој ефикасне стратегије унапређења исхране и здравља (Honkanen and Frewer, 2009). Још увек се не знају психосоцијални фактори који имају утицај на ставове потрошача према новом прехрамбеном производу. Претпоставља се да ће потрошачи пре да прихвате нови производ ако поменута намирница обезбеђује одређене здравствене бенефите (Milner et al., 2020).

У циљу сагледавања прихватања новог производа спроведено је истраживање прихватљивости кекса са 20% дехидрираног целера на 427 случајно одабрана потрошача различитих социодемогравских карактеристика (старост, ниво образовања, висина примања и пол). Анкета се састоја од две врсте питања, питања општег карактера и специфична питања везана за нов производ (табела 9).

Табела 9. Питања за анкету потрошача (Filipović et al., 2024)

Врста питања	Информација/ бр питања	Информације/ питања	одговори/резултат
Опште информације	И1	Старост потрошача	<18 г./18-30 г. /31-50 г./>51 г.
	И2	Ниво образовања	Основна школа/ средња школаl/ факултет/ Универзитет
	И3	Висина прихода	ниско/средње/ високо/највише
	И4	Пол	мушко/женско
Општа питања	П1	Да ли читате декларацију на паковању кекса?	Одговор: Да/Не
	П2	Да ли ваше здравствено стање захтева посебну исхрану?	
	П3	На основу вашег мишљења, да ли врста исхране утиче на здравствено стање?	
Специфична питања	П4	Да ли је боја кекса прихватљива?	Резултат: Од 1 до9, 1 –најмањи, 9 највећи
	П5	Да ли је укус кекса прихватљив?	
	П6	Да ли је мирис кекса прихватљив?	
	П7	Да ли је цена кекса важана за одлуку о куповини?	
	П8	Да ли желите овај кекс да укључите у редовну исхрану?	

На основу резултата анкете може се закључити да су потрошачи у свим социо-демографским групама били добро свесни значаја декларација производа и интеракције између исхране и здравља, иако је мало њих имало специфичне потребе у исхрани (34.09±0,18) и то популација старија од 50 година. Боја, укус и мирис новог производа

били су широко прихваћени (7 до 8) без обзира на различите социодемографске карактеристике испитаника (Filipović et al., 2024)
Резултати процене прихватљивости новог производа од стране потрошача показали су да велика група (427) насумично одабраних потрошача има висок степен прихватљивости кекса са дехидринаним целером, на основу сензорских карактеритика производа. Потрошачи су показали висок позитиван став према новом производу и указали на његов велики потенцијал за тржишну прихватљивост.

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Извод:

Применом комбинованог метода дехидратације који обухвата енергетски незахтеван осмотски предтретман у меласи и сукцесивни, скраћени, високоенергетски поступак лиофилизације, на економски и енергетски унапређен начин се добија прах целера обогаћен вредним нутритивним компонентама из меласе. Меласа је споредни производ идустрије шећера и данас се сматра јефтиним извором нутритивних компнети које се враћају у ланац исхране, применом комбиновог метода дехидратације, што утиче на одрживост и економску рентабилност прехрамбене индустрије.
Последњих година се значајно променило мишљење о статусу хране. Данас је пехрамбена идустрија усмерена према квалитету и безбедности прехрамбених производа, а храна добија додатне функције - да спречи болести повезане са исхраном и побољша физичко и ментално стање потрошача.
Кекс је производ који се скоро свакодневно конзумира у различитим облицима и доступан је великој популацији, а његове нутритивне и енергетске карактеристике остављају простора за унапређење кроз иновације.
Кекс са додатком дехидрираног целера има знатно побољшан нутритиван и функционални састав што се огледа у смањењу садржаја липида и скроба, повећан садржај целулозе и смањену енергетску вреднст за 20%, знатно повећан минерални састатв и антиоксидативни потенцијал. Кекс са дехидрираним целером је иновативни производ доброг технолошког квалитета и сензорских карактеристика кога карактерише висок степен прихватања од стране потрошача различитих социодемографских карактеристика.

Прилог 1.

Машинско – технолошка опрема погона за производњу сланог кекса са дехидрираним целером

Редни број	Назив опреме са техничким подацима	Јед. мере	Кол.
1	**Радни сто за припрему сировину,** металне конструкције и радне плоче од нерђајућег челика димензија:1600 x 800x 850 mm	Ком.	1
2	**Покретни сандук за брашно** металне конструкције димензије: 600 x 750 x 700 mm (запремине 300l)	Ком.	2
3	**Стона вага за одмеравање помоћних сировина** опсега мерења од 5 kg, димензије 450 x 350 mm са приклључком на елктромеражу, потрошња ел. енергије N=0,2 kW/h	Ком.	1
4	**Једноделни судопер** од нерђајућег челика са прикључцима за топлу и хладну воду, димензије:600 x 500 mm	Ком.	1
5	**Расхладна комора за чување сировина пре обраде** металне конструкције димензија:800 x 800 x 1500 mmm режим рада до -4°C, са компресором санаге N=0,55 kW	Ком.	1
6	**Спороходна месилица** металне конструкције димензија: 490 x690 x 610 mm, са одвојеном посудом од нерђајућег челика димензија Ø 360 mm, капацитета посудедо 10 kg теста по шаржи, комплент са свим припадајућим деловима са погоном снаге: N=0,75 kW	Ком.	1
7	**Уређај за округло обликовање теста** металне конструкције димензија:1055 x935 x 1410 mm опсега 10-300 g, капацитета до1000 kom/h Комплет са једним бубњем за граматуре и свим припадајућим деловима, са погоном снаге: N= 0,75 kW	Ком.	1
8	**Расхладна комора за хлађење тетса пре обраде** металне конструкције димензија: 800 x 800 x 1500 mm режим рада до -4 °C, са компресор снаге: N= 0,55 kW	Ком.	1
9	**Радни сто**	Ком.	2

	са металном конструкцијом и радном плочом од куване буковине и металном полицом димензија: 300 x 850 x 850 mm		
10	**Ламинатор** металне конструкције са бесконачном траком од филцаног материјала димензија: 2500 x 1025 x 1300 mm са погоном снаге: N=0,90 kW	Ком.	1
11	**Уређај за исецање тетсаних комада** металне конструкције капацитета: 50-100 kg/h димензија: 1200 x 1000 x 1250 mm са погоном снаге: N=0,90 kW	Ком.	1
12	**Четвороетажна парана пећ** металне конструкције димензија: 2650 x 2850 x 2000 mm укупне грејне површине 5,0 m^2 комплет са свин припадајућим деловима, горионико за гасно гориво, димоводом, прикључком на водоводну мрежу, мотором вентилатора снаге	Ком.	1

Листа раније прихваћених техничких решења аутора:

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Потврда:

СЛАНИ КЕКЕКС СА ДЕХИДРИРАНИМ ЦЕЛЕРОМ

Произвођач: "КОРНИ" д.о.о
Београдска 39,
85 000 Бар,
Црна Гора

Произвођачка спецификација сланог кекса дехидрираног целера:

Хемиски састав	
Протеини (% с.м.)	9,7
Скроб (% с.м.)	38,1
Ук. шећери (% с.м.)	6,8
Целулоза (% с.м.)	0,6
Липиди (% с.м.)	18,4
Пепео (% с.м.)	1,4
Енергетска вреднсот (kJ/g)	1614,3
Минерални састав	
K (mg/100g с.м.)	438,5
Mg (mg/100g с.м.)	22,0
Ca (mg/100g с.м.)	43,6
Fe (mg/100g с.м.)	2,1
Zn (mg/100g с.м.)	0,6
Cu (mg/100g с.м.)	0,4

Рецептура сланог кекса са дехидрираним целером

	Количина (%)
Брашно (%)	80
Дехидрирани целер (%)	20
База за обрачун: маса брашна	
Маргарин (g)	28,5
Шећер (g)	1
NaCl (g)	0,9
$NaHCO_3$ (g)	1
Вода (g)	22

Производња „***Сланог кекса са дехидрираним целером***" одвија се у стандардном делу погона ,,КОРНИ" д.о.о. за кондиторски производни програм, капацитета 100 kg/дан. Капацитет производне линије кекса са дехидрираним целером је 5 kg/h.

Линија за производњу сланог кекса са дехидрираним целером састоји се од:

- месилице,
- уређаја за округло обликовање теста,
- расхладне коморе,
- ламинатора,
- уређаја за исецање тестаних комада и
- пећи за печење кекса.

Након печења производ се хлади до собне температуре и ставља у продају кроз малопродајни ланац произвођача.

КОРНИ д.о.о
Директор:
Стеван Главичић, дипл. инж

ИЗЈАВА КОРИСНИКА ТЕХНИЧКОГ РЕШЕЊА

КОРНИ д.о.о

СЛАНИ КЕКС СА ДЕХИДРИРАНИМ ЦЕЛЕРОМ

На основу Уговора о продаји техничког решења, број 17/90 од 12.09.2024. закљученог између Научног института за прехрамбене технологије у Новом Саду, са седиштем у Републици Србији, у Новом Саду на адреси Булевар цара Лазарц број 1, МБ: 08865485, ПИБ: 104743019, којог заступа др. Љубиша Шарић, в.д. директор Института и ,,КОРНИ" д.о.о., са седиштем у Бару, Црна Гора на адреси Београдска 39, 85000 Бар, Црна Гора, РБ: 50053700, ПИБ: 02358913, кога заступа Стеван Главичић:

Изјављујем да је КОРНИ д.о.о., корисник техничког решења ,,СЛАНИ КЕКС СА ДЕХИДРИРАНИМ ЦЕЛЕРОМ", који је настао као производ закљученог Уговора о нпродаји техничког решења, потписаног као резултат остваривања заједнидких интереса у развоју научноистраживачке делатности и комерцијализације резултата научноистраживачког рада између горе наведених уговорних страна.

Као корисник резултата овог техничког решења узели смо активно учешће у реализацији уговора у делу обезбеђивања свих неопходних услова за остваривање одређених задатака предвиђених уговором. Циљ коришћења наведеног техничког решења је да се подигне технолошки ниво производње, побољша квалитет производа и рационализују трошкови.

У Бару, дана

23.09.2024 god.

КОРНИ д.о.о

Одговорно лице корисника техничког решења

Стеван Главичић

Директор:

"KORNI" d.o.o. BAR

foods

MDPI

Article

Quality Optimization and Evaluation of New Cookie Product with Celery Root Powder Addition

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Abstract: Combined drying, an energy-efficient method that includes osmotic pretreatment in molasses and shortened successive lyophilization, was used to obtain celery root powder and incorporate it in the formulation of cookies, with the aim of obtaining a new product. Wheat flour was substituted with combinedly dehydrated celery root powder at levels from 0 to 30%, and optimization of the amount of wheat flour substitution regarding technological, sensory and nutritive characteristics was performed. The optimal level of 20% substitution was determined using Z-score analysis, from the aspect of the best nutritive improvement and the mildest adverse impact on the technological and sensory quality. In the second research phase, comparison of the cookies with the 20% celery root powder substitution, dehydrated by different methods, indicated that combined dehydration showed upgraded results in terms of the overall quality of the final product, for 28.85 percentile points higher than cookies with lyophilized and for 65.24 percentile points higher than cookies with the addition of convectively dried celery root powder. The cookie containing celery powder previously osmodehydrated in molasses had higher contents of analyzed minerals (1.2–3.3 times), total phenols (10.8%) and antioxidant activities (14% for DPPH and 4% for ABTS) compared to the cookie with lyophilized powder.

Keywords: combined dehydration; convective drying; lyophilization; *Apium graveolens* L. powder; molasses; biscuit

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1. Introduction

Celery root (*Apium graveolens* L.), a plant of the *Apiaceae* family, contains many compounds beneficial to health, including dietary fibers (primarily cellulose, hemicellulose and pectin), minerals (significant amounts of K, Ca, Mg, P, Zn, Fe), numerous vitamins and essential oils [1–3]. Various studies have confirmed the great presence of phenolic compounds and other phytochemicals in celery root (kaempferol, luteolin, apigenin, quercetin, caffeic acid, ferulic acid, p-coumaric acid, tannins, saponins), which are responsible for its pronounced antioxidant, anti-inflammatory and antimicrobial characteristics and role in the prevention of many diseases and disorders [4–7]. Due to its characteristic organoleptic properties, aromatic smell and pungent taste, celery root is mainly consumed in the daily diet as a vegetable or as a spice in cooking, while its use as an ingredient in food products is limited [8,9].

Although convective drying is one of the most relevant methods for dehydrating vegetables, many studies indicate the disadvantages of this procedure caused by the application of high temperatures, which affect the loss of color, deterioration of texture, change in taste and loss of important nutrients [9,10]. Conversely, the lyophilization method provides great potential for preserving the nutritional and sensory qualities of dried products but at the same time contributes to the increase in process costs and process execution time [11,12]. Using the combined dehydration method presented by the authors Filipović et al. [13], which includes low-energy osmotic pre-treatment in molasses and an abbreviated successive procedure of high-energy-demanding lyophilization, dehydrated raw material enriched with valuable nutrients from molasses is obtained in an economical and energy-enhanced way.

Nowadays, particular focus is on increasing the use value of secondary products of the food industry (such as the above-mentioned sugar beet molasses), which are good sources of natural antioxidants, minerals and other functional ingredients that can be used to enrich food products [14,15]. In addition to the ecological advantage, the implementation of molasses as an osmotic solution in the process of osmotic dehydration is simple; it does not require energy consumption or elevated temperatures. By immersing fresh vegetables in molasses, due to the concentration gradient between the highly concentrated and highly hydrated material, the multicomponent mass transfer results in the loss of water from the submerged vegetable tissue, into which the components from the molasses are simultaneously incorporated [16–18].

The consumption of cookies has been widely popularized due to their good shelf life, ready-to-eat form, recognizably pleasant taste and texture and economic availability [19]. The cookies are traditionally produced from wheat flour, with a high percentage of fat and carbohydrates and a small amount of dietary fiber, minerals and other functional components, which can have a negative impact on the health of people who regularly consume them, especially excessively [20,21]. With increasing living standards and health awareness, there is a greater demand for the production of cookies with improved nutritional and functional value [22,23]. The cookie can be a good candidate for the production of upgraded quality food because its nutritional value can be improved by changing its basic composition by flour substitution or supplementation with health-promoting ingredients [22–24]. Since any change in the standard dough formulation affects the final sensory and textural properties of the newly formulated cookie, it is necessary to carefully select and optimize the amounts of the ingredients in order to meet consumer expectations [21,25].

The goal of the research was structured in two consecutive phases. In the first phase, the goal was set to define the optimal substitution amount of wheat flour with osmodehydrated and lyophilized celery root powder in the cookie, in which the most favorable technological and nutritive profiles were achieved. In the second phase, the influence of different dehydration methods (combined osmodehydration and lyophilization, convective drying and lyophilization) on the same technological and nutritional parameters of cookies with the optimal addition of celery powder was examined.

2. Materials and Methods

2.1. Material

Fresh celery root (*Apium graveolens* L. var. *rapaceum*, Alabaster variety) was acquired at the local greengrocery in Novi Sad (Serbia), of which the average dry matter content was 9.05%. Sugar beet molasses, used as an osmotic solution in the osmotic pretreatment, was obtained from a sugar factory in Crvenka, Serbia, with an average dry matter content of 86.04%. The following material was used for the preparation of cookies: white wheat flour, type T-400 (moisture content of 14%), produced by “Danubius”, Novi Sad, Serbia; margarine produced by “AD Dijamant”, Zrenjanin, Serbia; sugar produced by “Šajkaška” Žabalj, Serbia; NaCl produced by “SO Produkt”, Stara Pazova, Serbia; and $NaHCO_3$, produced by “Aleva”, Novi Kneževac, Serbia.

2.2. Combined Method of Dehydration

The combined method of celery root dehydration was carried out in two stages: first the process of osmotic dehydration in molasses, and then lyophilization. Fresh celery root was initially washed with running tap water, dried with paper towels, peeled and cut into cubes of approximately 1 cm × 1 cm × 1 cm. Then the celery cubes were immersed in vessels filled with enough molasses to obtain dehydrating material in an osmotic solution ratio of 1:5 in an effort to prevent excessive dilution of the molasses and slowing down the kinetics of the process. The osmotic dehydration process took place for 5 h at atmospheric pressure in a thermostatic chamber (Memmert IN160, Schwabach, Germany) where the temperature was set and maintained at 20 °C. After 5 h, the osmotically treated celery samples were separated from the molasses, washed with running water to remove excess solution on the surface of the cubes and then blotted with paper towels to remove excessive water. Obtained osmotically dehydrated celery samples were frozen and stored at −30 °C for 24 h and then subjected to the lyophilization process, using the following device: Christ ALPHA1-2 LDPLUS (Osterode am Harz, Germany). The lyophilization parameters were set at the following: pressure of 1.6 Pa, condenser temperature of −57 °C, shelf temperature at room temperature and a process duration of 24 h. After lyophilization, dehydrated samples were finely ground into a powder of uniform particle size using a universal laboratory mill, type WZ-1 (Solem, ZBPP, Bydgszcz, Poland).

2.3. Convective Drying

Diced celery samples were dried to a constant mass in a dryer (Instrumentaria, Zagreb, Croatia) at 50 °C and then pulverized using a universal laboratory mill, type WZ-1 (Solem, ZBPP, Bydgoszcz, Poland), to obtain convectively dried celery root powder.

2.4. Lyophilization

Fresh samples of diced celery were previously frozen for at least 24 h and then were placed on metal trays of a freeze-dryer (Christ ALPHA1-2 LDPLUS, Osterode am Harz, Germany). The lyophilization process was set to the same parameters as in Section 2.2, with the difference being that the time required to obtain the dried samples was 48 h. After this time, the samples were ground using a universal laboratory mill, type WZ-1 (Solem, ZBPP, Bydgoszcz, Poland).

2.5. Cookie Samples Preparation

The design of an experimental plan was based on different cookie dough formulations, which included the standard (sample 1) and modified formulations. The first phase of research defined the first seven cookie sample formulations, where osmodehydrated and lyophilized celery root powder substituted for different quantities of wheat white flour (from 5% wheat white flour substitution with celery powder in sample 2 to 30% in sample 7). After performing the cookies' quality optimization and defining the optimal level of wheat white flour substitution, in the second phase of the research, two more samples (8 and 9) were produced, where the same level of substitution was done but with different types of celery root dehydration methods (convective drying, sample 8; lyophilization, sample 9).

In Table 1, the formulations of all produced samples in both phases of the research are presented.

The cookie preparation included dough production operations such as mixing, processing and baking in a pilot plant for bakery products of the Institute for Food Technology in Novi Sad, Serbia, in accordance with the AACC method 10–50 D [26], as described by Šobot et al. [17].

Table 1. Experimental design of the flour substitution with dehydrated, pulverized celery root and formulation for tested cookie samples.

Research Phase:	The First							The Second	
Sample no:	1	2	3	4	5	6	7	8	9
Wheat white flour (%)	100	95	90	85	80	75	70	80	80
O.D. + L. celery root (% dry matter (d.m.)) *	0	5	10	15	20	25	30	0	0
C.D. celery root (% d.m.) **	0	0	0	0	0	0	0	20	0
L. celery root (% d.m.) ***	0	0	0	0	0	0	0	0	20
Cookie samples formulation, uniform for all samples									
Wheat white flour/flour mixture (g)	56.25								
Margarine (g)	16.00								
Sugar (g)	0.56								
NaCl (g)	0.53								
$NaHCO_3$ (g)	0.63								
Tap water (g)	12.50								

* Osmotically dehydrated and lyophilized, pulverized celery root. ** Convectively dried, pulverized celery root. *** Lyophilized, pulverized celery root.

2.6. Technological Parameters Analysis

The technological quality parameters of the cookies were determined by the AACC 10–50D [26] method. Baking weight loss (BWL) was determined by measuring the weight of cookies before and after the baking stage using Equation (1):

$$\text{BWL } (\%) = \frac{m_0 - m_t}{m_0} \cdot 100 \quad (1)$$

where, m_0 is the cookie's weight before baking (g) and m_t is the cookie's weight after baking (g). Analysis was performed on six samples.

Drying weight loss (DWL) was determined by measuring the weight of cookies after the baking stage and after 30 min of cooling at the room temperature, using Equation (2):

$$\text{DWL } (\%) = \frac{m_{0'} - m_{t'}}{m_{0'}} \cdot 100 \quad (2)$$

where, $m_{0'}$ is the cookie's weight after baking (g) and $m_{t'}$ is the cookie's weight after 30 min of cooling (g). Analysis was performed on six samples.

Measurements of cookies' dimensions were performed after a 30 min cooling period. Measurements were made of the cookie diameter in the lamination direction (length–L), the cookie diameter perpendicular to the lamination direction (width—W) and cookie thickness (T). The average cookie diameter (R) was determined by the lowest W and the highest L. T was measured by stacking six cookies and measuring their total height. After the first measurement, the six cookies were rearranged into a column, and their height was measured again. Finally, the mean of these measurements was divided by the number of cookies (6) to calculate the mean value of the cookies (T). The expansion factor (R/T) was determined by the ratio of the mean values of R and T, which indicates the deformation of the cookie shape during baking.

2.7. Texture Instrumental Analysis

Cookie texture parameters were determined using the texture analyzer TA-XT2 Texture Analyser (Stable Micro Systems, Godalming, UK) equipped with a 25 kg load cell and Knife Edge with Shotted Insert HPD/bs tools. Measurements were performed by applying compression mode at the crosshead speed of 1 mm/s prior, 3 mm/s during and 10 mm/s after the analysis. Using Exponent Stable MicroSystems computer software, version 6.0, maximum force (n) and distance at break were recorded as a function of time and are indicators of cookie hardness. The measurement of the textural parameters of the cookies was performed in six repetitions, in each batch of cookies, 24 h after baking, at a temperature of 25 °C and dimensions of 50 mm × 50 mm.

2.8. Color Instrumental Analysis

Color parameters of the cookies' surfaces were determined in six replications, 24 h after baking, using a Chroma meter (CR-400, Konica, Minolta, Tokyo, Japan) tri-stimulus colorimeter (contact surface diameter: 8 mm). Before measuring the samples, calibration was done using a white color standard. The results of the color analysis are presented according to the CIElab color system, where the coordinates are defined as follows: L—brightness (from 0 (black) to 100 (white)), a—greenness/redness (from −a (green) to +a (red)) and b—blueness/yellowness (from −b (blue) to +b (yellow)) [17,27].

The color variation between the control sample and samples with the celery powder addition (ΔE) was determined by Equation (3):

$$\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2} \quad (3)$$

where ΔL is the difference in the L parameter between the control and the cookie sample with the celery powder addition, Δa is the difference in the a parameter between the control and the cookie sample with the celery powder addition and Δb is the difference in the b parameter between the control and the cookie sample with the celery powder addition. The measurement of the instrumental color parameters of the cookies was performed in three repetitions.

2.9. Descriptive Sensory Analysis

In an effort to obtain a sensory profile of the cookie samples, a panel of ten evaluators with previous experience in evaluating various food products was formed according to the appropriate standard: ISO 6658:2017 [28]. The selection of descriptors for the sensory profiling of the cookie samples using the descriptive sensory method was previously performed by the leading evaluator and further adjusted by the rest of the evaluators to better define the sensory profiles of the cookies. The final list comprised six descriptors, where two descriptors characterized cookie appearance (color intensity and surface appearance), one descriptor characterized deviation from the standard taste, one descriptor characterized deviation from the standard odor and two descriptors were used for the textural properties definition (sensory hardness and fracturability). A seven-point scale described the intensity of each descriptor, where 1 was marked as the lowest intensity and 7 as the highest intensity [29], except for descriptors for taste and odor where optimal descriptor values were set to value 4 and deviations from this value were characterized by different cookie sample sensory attributes.

Sensory testing of each cookie sample was performed 24 h after baking in the sensory analysis laboratory of the Institute of Food Technology, Novi Sad, Serbia, and designed according to the ISO 8589:2007 standard [30]. The tasting began after panelists filled out the informed consent form following the Declaration of Helsinki guidelines. Cookie samples were served to the panelists on white plastic plates, coded by random three-digit codes from the table of random numbers. The evaluators were given enough water to rinse their mouths between each tasting.

2.10. Chemical Analysis

An approximation of the chemical composition of cookie samples was conducted according to AOAC standard methods [31]: protein content (method No. 950.36), starch content (method No. 996.11), total sugars content (method No. 2020.07), cellulose content (method No. 973.18), lipid content (method No. 935.38) and ash content (method No. 930.22). Each measurement was performed in three replications.

2.11. Minerals Analysis

The mineral contents of potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn) and copper (Cu) of the cookies were determined in accordance with the standard methods of AOAC [31]. Minerals were determined by atomic absorption spectrophotometry (method No. 984.27) on a Varian Spectra AA 10 (Varian Techtron Pty Ltd., Mulgvare, Melbourne, VIC, Australia). Each measurement was performed in three repetitions.

2.12. Phenol Content and Antioxidant Activity Analysis

For the determination of total phenol content and antioxidant activity, 2.5 mL ethanol, acetic acid and water (50:8:42) were mixed with 500 mg of powdered cookie sample on Vortex for 2 min, then centrifuged at 12,000 rpm for 3 min. The liquid part was collected and filtered through a 0.45 µm filter.

Total phenol contents in cookie extracts were determined by the Folin-Ciocalteau method adapted to microscale [32]. Results were expressed as mg gallic acid equivalents per 100 g cookie (mg GAE/100 g dry matter). The antioxidant activity was determined using two different methods of free radical scavenging: 2,2-diphenyl-1-picrylhydrazyl (DPPH) as described by Tumbas Šaponjac et al. [33] and 2,2′-azino-bis-3-ethylbenzothiazoline-6-sulphonic acid (ABTS) according to Aborus et al. [34]. Results were expressed as µmol of Trolox equivalents per 100 g cookie (µmol TE/100 g dry matter). Phenol content and antioxidant activity testing was performed in three repetitions.

2.13. Methods of Statistical Analysis

2.13.1. Analysis of Variance

Analysis of variance (ANOVA) was applied in order to determine the variations' statistical significance on the set of all cookie samples' tested quality responses. ANOVA analysis was performed by using STATISTICA 12.0 software (2013) (StatSoft Europe, Hamburg, Germany).

2.13.2. Z-Score Analysis

In the Z-score analysis, min-max normalization is used for cookie samples' different response values. They are recalculated and presented in a new dimensionless unit system, with the effort of comparisons and further mathematical calculations of different cookie samples' quality responses [7].

The maximum obtained value of total Z-score values indicates the optimum value of all segment Z-scores mathematically combined in a defined manner, pointing at the optimal combination of all tested quality parameters of cookie samples.

The calculation of individual segment Z-scores is as follows:

Cookie samples' technological quality segment Z-score:

$$S_{1i} = \frac{\sum_{k=1}^{4}\left(1 - \frac{x_{ki} - x_{kmin}}{x_{kmax} - x_{kmin}}\right) + \left(\frac{x_{ji} - x_{jmin}}{x_{jmax} - x_{jmin}}\right)}{5} \tag{4}$$

where x_k are BWL, DWL, R and R/T, and x_j is T.

Cookie samples' texture instrumental analysis segment Z-score:

$$S_{2i} = \frac{\sum_{l=1}^{2}\left(1 - \frac{x_{li} - x_{lmin}}{x_{lmax} - x_{lmin}}\right)}{2} \tag{5}$$

where x_l are hardness and fracturability.

Cookie samples' color instrumental analysis segment score:

$$S_{3i} = \frac{\sum_{m=1}^{3}\left(\frac{x_{mi} - x_{mmin}}{x_{mmax} - x_{mmin}}\right) + \left(1 - \frac{x_{ni} - x_{nmin}}{x_{nmax} - x_{nmin}}\right)}{4} \tag{6}$$

where x_m are L, a and b, and x_n is ΔE.

Cookie samples' descriptive sensory analysis segment score:

$$S_{4i} = \frac{\sum_{n=1}^{3} \left(1 - \frac{x_{oi} - x_{omin}}{x_{omax} - x_{omin}}\right) + \left(\frac{x_{pi} - x_{pmin}}{x_{pmax} - x_{pmin}}\right)}{6} \quad (7)$$

where x_o are color intensity, hardness and fracturability, and x_p are surface appearance, taste and odor.

Cookie samples' chemical composition segment Z-score:

$$S_{5i} = \frac{\sum_{r=1}^{5} \left(\frac{x_{qi} - x_{qmin}}{x_{qmax} - x_{qmin}}\right) + \left(1 - \frac{x_{ri} - x_{rmin}}{x_{rmax} - x_{rmin}}\right)}{6} \quad (8)$$

where x_q are proteins, starch, total sugar, cellulose and ash, and x_r is lipids.

Cookie samples' mineral matter content segment Z-score:

$$S_{6i} = \frac{+\sum_{s=1}^{6} \left(\frac{x_{si} - x_{smin}}{x_{smax} - x_{smin}}\right)}{6} \quad (9)$$

where x_s are K, Mg, Ca, Fe, Zn and Cu.

Cookie samples' phenol content and antioxidative activity segment Z-score:

$$S_{7i} = \frac{\sum_{t=1}^{3} \left(\frac{x_{ui} - x_{umin}}{x_{umax} - x_{umin}}\right)}{3} \quad (10)$$

where x_u are total phenolic content, DPPH and ABTS.

Total quality cookie samples' Z-score:

$$S_i = 0.15 \cdot S_{1i} + 0.05 \cdot S_{2i} + 0.1 \cdot S_{3i} + 0.20 \cdot S_{4i} + 0.20 \cdot S_{5i} + 0.2 \cdot S_{6i} + 0.1 \cdot S_{7i} \quad (11)$$

where cookie samples' technological quality characteristics Z-score values (S_{1i} to S_{3i}) contribute 30%, descriptive sensory characteristics Z-score values (S_{4i}) contribute 20% and nutritive quality characteristics Z-score values (S_{5i} to S_{7i}) contribute 50% to the total Z-score, or total quality.

$$\max\,[S_i] \rightarrow \text{optimum} \quad (12)$$

Z-score values were calculated using Microsoft Excel ver. 2016. (Microsoft Corporation, Redmond, WA, USA).

2.13.3. Principle Component Analysis

Principal component analysis (PCA) was applied as a pattern recognition technique for data analysis. XLSTAT Version 2014 5.03 Add-in (Lumivero, Denver, CO, USA) in Microsoft Excel ver. 2016. (Microsoft Corporation, Redmond, WA, USA) software was used for the PCA calculation.

3. Results and Discussion

3.1. Technological Quality of Cookies

Replacing wheat flour with any material in the basic formulation of cookies can distinctly change their physicochemical properties, primarily parameters that define technological quality, such as cookie geometry and texture profile [24,35]. During mechanical mixing, the raw materials used in the composition of the cookies interact to finally form a unique shape, consistency, appearance, color and taste in the last stage of baking [25,36]. The influence of substituting flour with combined dried celery root powder at the level of

5 to 30% on the parameters chosen to characterize the technological quality of cookies is shown in the Table 2.

Table 2. Cookie samples' technological quality.

Sample No:	BWL (%)	DWL (%)	T (mm)	R (mm)	R/T
1	25.22 ± 0.51 ^e^	0.96 ±0.13 ^e^	55.05 ± 0.81 ^f^	97.05 ± 0.83 ^a^	1.76 ± 0.01 ^a^
2	21.37 ± 0.73 ^d^	0.91 ± 0.09 ^e^	53.12 ± 0.76 ^e^	98.43 ± 0.49 ^ab^	1.85 ± 0.02 ^b^
3	18.97 ± 1.04 ^c^	0.86 ± 0.06 ^de^	50.43 ± 0.63 ^d^	98.91 ± 0.39 ^a–c^	1.96 ± 0.02 ^c^
4	17.91 ± 0.44 ^bc^	0.77 ± 0.03 ^c–e^	49.74 ± 0.81 ^cd^	99.27 ± 0.23 ^b–d^	2.00 ± 0.03 ^c^
5	17.00 ± 0.46 ^ab^	0.65 ± 0.04 ^bc^	48.42 ± 0.49 ^bc^	99.73 ± 0.38 ^b–d^	2.06 ± 0.01 ^d^
6	16.59 ± 0.36 ^ab^	0.53 ± 0.05 ^ab^	47.12 ± 0.37 ^ab^	100.51 ± 0.73 ^cd^	2.13 ± 0.00 ^e^
7	15.96 ± 0.30 ^a^	0.37 ± 0.01 ^a^	46.24 ± 0.67 ^a^	101.12 ± 1.20 ^d^	2.19 ± 0.01 ^f^

BWL—baking weight loss, DWL—drying weight loss, T—cookie samples' thickness, R—average diameter, R/T—diameter-to-thickness ratio; results are shown as average value ± standard deviation of six replications. [a–f] Different letters in superscript of the same table column indicate the statistically significant difference between values, at a level of significance of $p < 0.05$ (based on post-hoc Tukey HSD test).

Weight reductions during baking and drying are important indicators of technological quality because they indicate the final texture and yield of the finished product [37]. The results from Table 2 revealed that the addition of different quantities of pulverized celery root in cookie formulations exerted statistically significant influence on the baking weight reduction response. By increasing the amount of celery powder substitution (5%, 10%, 15%, 20%, 25%, 30%), there was a corresponding decrease in baking weight loss in samples 2–7 compared with control sample 1 (without combined dehydrated celery addition). A possible explanation for this observation could be found in the fact that the celery powder added to the cookies is a high cellulosic material compared to an adequate amount of wheat flour, scarce in insoluble dietary fiber [8]. Cellulose fibers can absorb a certain amount of water and probably thereby influence the better distribution of moisture in the dough, so during baking, when the temperature rises, water is more strongly bound, and less water is subject to evaporation [35,38]. This observation is consistent with the research of Wang et al. [8], where it was reported that the water absorption of wheat dough increases with the increase in added celery powder, while the gluten protein network is weakening. The drying weight loss parameters followed the same trend of a significant ($p < 0.05$) reduction with a percentage increase in the quantity of added dehydrated celery. The same proposed explanation that is related to a more uniform moisture distribution and a higher content of bound water in the dough can be attributed to the behavior of the drying weight loss in the tested cookie samples (2–7).

Factors that describe cookie dimensions (thickness, average diameter and diameter-to-thickness ratio) are important for defining the influence of additives on its technological characteristics and the quality control of the finished product [35,37]. The thickness of the cookie is a consequence of the formation of the dough structure during baking through setting the balance between the gluten protein coagulation and the expansion of the dough, due to the steam creation and gas release from leavening agents [24,37]. The addition of dehydrated celery root powder led to a destabilization of the dough structure, which resulted in a decrease in the cookie's thickness (2–7) compared to the control sample (1). Even the smallest addition level of 5% (sample 2) caused a statistically significant decrease in the thickness of the cookie, and an increase in the addition up to 30% led to obtaining even thinner cookies. Similar results were reported by Wang et al. [8] and Lauková et al. [39], where the addition of celery root powder caused the reduction of a specific volume in breads. These authors stated that replacing wheat flour with celery powder disrupts the homogeneity and continuity of the gluten network, resulting in bread with a lower specific volume and more compact gas cells. The average diameter response, which indicates the extent of dough spread during baking [35], showed the reverse trend. After the addition of celery root powder in an amount greater than 10% (samples 4–7), the diameter of the cookie was statistically significantly increased compared to the control. The combination of the same factors during the dough formation and baking that affect thickness also affects the final diameter and diameter-to-thickness ratio of the cookie. The value of the R/T ratio indicates the extent of a cookie's shape deformation [27,35]. Increasing the quantity of celery powder in the formulation of the samples (2–7) caused linearly increased shape deformation, statistically significant at all addition levels.

3.2. Textural Parameters of Cookies

In Table 3, the results of instrumental texture analyses of the hardness and fracturability, key parameters on the basis of which consumers evaluate the quality of cookies, are presented. Hardness is defined by the force required to cause complete breaking of the cookie, while fracturability is an indicator of the texture's fragility and its tendency to crumble [25,36]. With a percentage increase in celery powder content (2–7), there was an increase in cookie hardness, ranging from 2091 to 5299 N, for the cookie samples 1 and 7, respectively. The increase in cookie hardness was directly proportional to the increase in the level of incorporated combinedly dehydrated celery root powder, and these values were statistically significantly higher with the samples containing higher levels of substitution compared to the control sample. However, the differences were not statistically significantly pronounced between samples 2 and 3 in comparison to the control cookie. Sample 7, with a 30% addition level of celery root powder, has the highest value of hardness, about 2.5 times more than the control cookie. This outcome is expected and in agreement with the research of several authors: Galla et al. [25] observed increased hardness of cookies with the addition of spinach powder at a 5–15% level; Sowmya et al. [40] proved that basil-incorporated cookies were harder compared to control cookie; Drisya et al. [41] noticed that cookies' hardness increased with increased addition of dried *Murraya koenigii* powder; Deepali and Roji [42] reported that biscuits with increased concentrations of coriander powder (10–30%) had greater hardness. All of these studies showed that firmness tends to rise with the addition of fiber content in cookies, because polysaccharides mechanically interfere with gluten proteins' interaction, reducing their ability to form a strong network. In addition, since fiber absorbs water, the amount of water available for hydration and development of the gluten matrix decreases, leading to a dilution of the gluten protein concentration, which results in a harder cookie texture [25,40,43]. Accordingly, the increased hardness in tested samples compared to the control cookie could be explained by substitution of wheat flour with a corresponding quantity of combinedly dehydrated celery root powder—cellulose-rich material.

Table 3. Cookie samples' textural analysis responses.

Sample No:	Hardness (N)	Fracturability (mm)
1	2091.73 ± 193.53 ^{a}	1.30 ± 0.20 ^{a}
2	2483.43 ± 204.43 ^{ab}	1.71 ± 0.12 ^{ab}
3	2798.05 ± 424.90 ^{ab}	2.09 ± 0.09 ^{bc}
4	3297.34 ± 241.17 ^{bc}	2.27 ± 0.19 ^{cd}
5	3923.50 ± 300.53 ^{cd}	2.49 ± 0.16 $^{c–e}$
6	4643.45 ± 401.27 ^{de}	2.65 ± 0.21 ^{de}
7	5299.71 ± 534.12 ^{e}	2.84 ± 0.25 ^{e}

Results are shown as average value ± standard deviation of six replications; $^{a–e}$ different letters in superscript of the same table column indicate the statistically significant difference between values, at a level of significance of $p < 0.05$ (based on post-hoc Tukey HSD test).

It can also be observed that the results for cookie fracturability follow the same trend. The addition of increasing amounts of celery powder from 0 to 30% led to statistically significantly enhanced values of samples' fracturability. It was noticeable that the fracturability of the cookies increased with the increase in the fiber content by including non-gluten raw materials (celery and molasses) in the cookie's formulation, which can interfere with the formation of the gluten matrix by the same mechanism as that proposed in the case of the hardness response discussion [40,42]. These results are correlated with the investigation of Parul et al. [44], where the incorporation of high-fiber spirulina and sorghum flours indicated a higher fracturability of biscuits.

3.3. Color Parameters of Cookies

Color is considered an essential factor that directly affects the perception and acceptability of the product by consumers [24]. Four instrumental color parameters of cookies fortified with different levels of combinedly dehydrated celery root powder are presented in Table 4. The results revealed that addition of osmotically pre-treated celery root powder statistically significantly reduced the brightness of cookies in all tested samples, as compared to the control cookie. The contribution to darkening was more pronounced as more celery powder was added to the cookie. This outcome could be attributed to the content of molasses in the combinedly dehydrated celery root powder, which, owing to the presence of colored substances, contributed to the darker color of the final products to which it was added. This was confirmed by the research of Šobot et al. [17] and Filipović et al. [27], where the darker color of the cookies was due to the addition of raw materials (wild garlic, peach) that have been subjected to the osmotic dehydration in molasses. The dark color of sugar beet molasses is a consequence of the formation of melanoidins and caramelization products during the production of sucrose, with the intensity of the melanoidins' color being up to six times more pronounced than other present colored substances [45,46].

Table 4. Cookie samples' instrumental color analysis responses.

Sample No:	L	a	b	ΔE
1	57.79 ± 1.01^{f}	6.55 ± 0.13^{ab}	22.72 ± 0.29^{f}	0
2	55.19 ± 1.09^{e}	6.81 ± 0.19^{ab}	20.19 ± 0.18^{e}	3.64 ± 0.02^{a}
3	50.97 ± 0.51^{d}	7.35 ± 0.28^{bc}	18.11 ± 0.13^{d}	8.27 ± 0.52^{c}
4	46.53 ± 0.61^{c}	8.24 ± 0.47^{cd}	16.01 ± 0.29^{c}	13.22 ± 0.38^{d}
5	41.98 ± 0.37^{b}	8.99 ± 0.57^{de}	14.83 ± 0.30^{b}	17.84 ± 0.62^{e}
6	39.68 ± 0.49^{ab}	9.37 ± 0.30^{e}	13.71 ± 0.20^{a}	20.42 ± 0.52^{f}
7	37.61 ± 0.78^{a}	9.67 ± 0.39^{e}	12.97 ± 0.17^{a}	22.63 ± 0.29^{g}

L—brightness, a—greenness/redness, b—blueness/yellowness, ΔE—color variation. Results are shown as average value ± standard deviation of six replications. [a–g] Different letters in superscript of the same table column indicate the statistically significant difference between values at a level of significance of $p < 0.05$ (based on post-hoc Tukey HSD test).

The cookies supplemented with celery root powder showed an increase in the share of red tone, proportional to the increase in the level of the supplement, ranging from 6.55 to 9.67, although the differences in cookies' redness between samples 1–3, 4–5 and 6–7 were not statistically profound. The cookies enriched with increasing levels of celery root powder trended in the opposite direction in terms of yellowness. Proportional augmentation of celery root powder quantity led to a statistically significant decline in yellow tone compared to the control sample. Based on the measured values of color variations, it can be seen that the addition of combinedly dehydrated celery root had a statistically significant effect on the deviation in the color of the tested samples in relation to the color of the control sample. The most noticeable variation in color was recorded in samples 5–7, where the additive level was higher (20, 25 and 30%), while in cookies 2–4, color change was moderately expressed (ΔE = 3.64–13.22).

3.4. Sensory Profile of Cookies

Sensory assessment plays an important role during the creation of a new product, and it can be used to define the limits within which it is possible to substitute or incorporate the new addition in formulation without significantly impairing products' quality or consumers' acceptability [19,43]. The data related to sensory evaluation of tested cookies with dehydrated celery root previously osmotically treated in molasses are presented in Table 5, from which it can be seen that color intensity followed the same trend as instrumental color measurement for the parameter of brightness. With an increase in the quantity of incorporated celery root powder, there was a statistically significant augmentation in the intensity of the color of the cookie, i.e., a darker appearance of the products. The intensity of the color of the control sample (1) was rated with grade 3.5 as a light ruddy (optimal color), and the addition in the amount from 5% to 30% of celery dehydrated by the combined method (samples 2–7) increased the color from slightly dark to extremely dark.

Table 5. Cookie samples' descriptive sensory analysis responses.

Sample No:	Color Intensity	Surface Appearance	Taste	Odor	Hardness	Fractur-Ability
1	3.5 ± 0.2^{ab}	5.9 ± 0.3^{e}	4.0 ± 0.0^{b}	4.0 ± 0.1^{c}	3.0 ± 0.2^{a}	4.0 ± 0.0^{a}
2	4.1 ± 0.3^{bc}	5.3 ± 0.2^{de}	3.8 ± 0.2^{b}	3.9 ± 0.1^{c}	3.5 ± 0.3^{ab}	4.6 ± 0.0^{ab}
3	4.5 ± 0.3^{cd}	4.5 ± 0.6^{cd}	3.6 ± 0.4^{b}	3.7 ± 0.4^{c}	$4.2 \pm 0.5^{a\text{-}c}$	4.9 ± 0.7^{ab}
4	5.1 ± 0.4^{de}	3.9 ± 0.6^{bc}	3.5 ± 0.1^{b}	3.6 ± 0.1^{c}	4.6 ± 0.3^{bc}	5.5 ± 0.0^{bc}
5	5.6 ± 0.2^{ef}	3.5 ± 0.4^{bc}	3.3 ± 0.5^{b}	3.5 ± 0.4^{c}	5.0 ± 0.5^{cd}	6.1 ± 0.1^{cd}
6	6.1 ± 0.3^{fg}	2.9 ± 0.2^{ab}	2.4 ± 0.2^{a}	2.6 ± 0.1^{b}	5.5 ± 0.5^{cd}	6.9 ± 0.1^{d}
7	6.6 ± 0.4^{g}	2.0 ± 0.3^{a}	2.0 ± 0.2^{a}	1.9 ± 0.1^{a}	6.1 ± 0.3^{d}	7.0 ± 0.0^{d}

Results are shown as average value ± standard deviation of ten replications (10 assessors). [a–g] Different letters in superscript of the same table column indicate the statistically significant difference between values at a level of significance of $p < 0.05$ (based on post-hoc Tukey HSD test).

With the increasing levels of addition of combinedly dehydrated celery root powder in cookies, statistically significant deterioration of cookie samples' surface appearance was observed.

It can be observed that the descriptors for the taste and odor with the increase in lyophilized celery root powder osmotically pre-treated in molasses deviated from the characteristic cookies' taste and odor, represented by cookie sample 1. In the samples that include the levels of celery root powder additions from 5% to 20% (samples 2–5), statistically insignificant deviation from the standard cookie taste and smell was noted. These findings could be related to the molasses content of the celery powder supplements, which probably masks the pronounced herbaceous and pungent notes derived from the celery.

The addition of 25% and 30% celery root powder to the cookies' formulations (samples 6 and 7), had a more adverse effect on the overall flavor, introducing statistically significant molasses notes to the cookies' sensory characteristics.

The results of sensory hardness and fracturability analysis are highly correlated with results obtained by instrumental textural analysis (Table 3), underlying that subjective experience of cookie consumption meets the instrumental analysis. Along with the increase in the level of addition of combinedly dehydrated celery root powder, the sensory hardness and fracturability of the cookies increased as well. The same ingredients interaction discussion, proposed in Section 3.2. Textural parameters of cookies, can be referred to for the discussion on the results of sensory hardness and fracturability.

3.5. Chemical Composition of Cookies

The results obtained from the analysis of the basic chemical composition of cookies prepared with a varied concentration of added combinedly dehydrated celery root powder and the cookie without the addition of celery powder are shown in Table 6.

It was noted that the addition of celery root powder led to a decrease in protein, starch and lipid content in samples 2–7 compared to the control. The content of starch and lipids in cookies proportionally and statistically significantly decreased at all increasing levels of addition, while for a statistically significant decrease in protein content, the amount of addition must be at least 10%. Protein, starch and lipid content in cookies declined from 10.85% to 8.91%, from 47.33% to 33.30% and from 23.07% to 16.15%, respectively, comparing the control cookie sample with the cookie sample with the highest quantity of substitution. Therefore, in sample 7, the most enriched with celery root powder (30%), compared to the sample with the standard formulation, the decrease in the content of these components was the most pronounced: 21.77% for protein content, 42.13% for starch content and 42.84% for lipid content. This can be explained by the fact that celery root and molasses, which were included in the cookie formulation as a substitute for an equivalent amount of wheat flour, are raw materials with low starch and fat contents and with a lower protein content compared to wheat flour. Similar results were reported by Mitrovski et al. [47], where with an increase in the share of beetroot powder in cookies up to 25%, protein content decreased from 9.17% to 8.94%, and fat content decreased from 25.55% to 25.11%.

Table 6. Cookie samples' chemical composition.

Sample No:	Proteins (% d.m.)	Starch (% d.m.)	Total Sugars (% d.m.)	Cellulose (% d.m.)	Lipids (% d.m.)	Ash (% d.m.)
1	10.85 ± 0.10^{e}	47.33 ± 0.27^{g}	2.17 ± 0.03^{a}	0.32 ± 0.01^{a}	23.07 ± 0.19^{g}	0.41 ± 0.00^{a}
2	10.65 ± 0.06^{e}	45.00 ± 0.34^{f}	3.35 ± 0.01^{c}	0.41 ± 0.01^{b}	21.99 ± 0.13^{f}	0.64 ± 0.01^{c}
3	10.27 ± 0.17^{d}	42.64 ± 0.38^{e}	4.59 ± 0.05^{d}	0.46 ± 0.01^{c}	20.70 ± 0.17^{e}	0.88 ± 0.00^{d}
4	9.99 ± 0.08^{d}	40.31 ± 0.43^{d}	5.70 ± 0.05^{e}	0.52 ± 0.00^{d}	19.61 ± 0.09^{d}	1.11 ± 0.00^{e}
5	9.67 ± 0.07^{c}	38.06 ± 0.39^{c}	6.84 ± 0.04^{f}	0.59 ± 0.01^{e}	18.43 ± 0.21^{c}	1.35 ± 0.01^{f}
6	9.24 ± 0.13^{b}	35.71 ± 0.30^{b}	7.99 ± 0.06^{g}	0.65 ± 0.00^{f}	17.20 ± 0.13^{b}	1.59 ± 0.01^{g}
7	8.91 ± 0.07^{a}	33.30 ± 0.27^{a}	9.09 ± 0.06^{h}	0.71 ± 0.01^{g}	16.15 ± 0.09^{a}	1.82 ± 0.01^{h}

Results are shown as average value ± standard deviation of six replications. $^{a–h}$ Different letters in superscript of the same table column indicate the statistically significant difference between values at a level of significance of $p < 0.05$ (based on post-hoc Tukey HSD test).

Conversely, cookies containing osmotically pre-treated celery root powder showed a statistically significant increase in total sugars, cellulose and ash content compared to the control sample. With the increase in the celery root powder share in cookies 2–7, the percentage of these components in the samples was higher, which may be explained by the relatively higher content of total sugars, cellulose and ash in celery root and molasses in comparison to the same quantity of wheat flour. Compared to the control cookie, the increase in total sugars, cellulose and ash content in tested cookies ranged from 1.5 to 4.1 times, from 1.3 to 2.2 times and 1.6 to 4.4 times, respectively, depending on the level of addition (5–30%). Thorat et al. [48] also confirmed that cookies incorporated with lemongrass powder show increased ash, crude fiber and carbohydrate content.

3.6. Mineral Composition of Cookies

Replacing wheat flour with lyophilized celery root previously osmodehydrated in molasses had a statistically significant positive effect on the mineral composition of cookies at all analyzed levels of substitution (Table 7). Since wheat flour contains minerals to a much lesser extent than other types of flour [20,23], increasing the proportion of celery powder including molasses, at a substitution level from 0 to 30%, caused increases in potassium content by 6.85 times, magnesium content by 45.27%, calcium content by 2.17 times, iron content by 2.14 times, zinc content by 1.77 times and copper content by 79.17%. Many studies correlate with these results. Somway et al. [40] reported that the incorporation of basil caused 35.21% higher potassium content, 42.47% higher calcium content, 200% higher iron content and 111.11% higher zinc content in cookies. Deepali and Roji [42] confirmed the improved contents of calcium, iron and phosphorous of biscuits fortified with 30% coriander powder. Agrahar-Murugkar [49] proved higher contents of calcium and iron in biscuits after fortification with cumin and moringa powder.

Table 7. Cookie samples' mineral contents.

Sample No:	K (mg/100 g d.m.)	Mg (mg/100 g d.m.)	Ca (mg/100 g d.m.)	Fe (mg/100 g d.m.)	Zn (mg/100 g d.m.)	Cu (mg/100 g d.m.)
1	90.63 ± 0.57 [a]	16.79 ± 0.15 [a]	24.54 ± 0.19 [a]	1.20 ± 0.01 [b]	0.39 ± 0.00 [a]	0.24 ± 0.00 [a]
2	179.50 ± 0.66 [c]	18.22 ± 0.18 [b]	29.43 ± 0.20 [b]	1.42 ± 0.00 [c]	0.48 ± 0.00 [b]	0.26 ± 0.00 [b]
3	265.84 ± 3.19 [d]	19.55 ± 0.18 [c]	33.99 ± 0.13 [c]	1.64 ± 0.01 [d]	0.53 ± 0.01 [c]	0.30 ± 0.00 [d]
4	353.43 ± 4.85 [e]	20.79 ± 0.16 [d]	39.00 ± 0.45 [d]	1.89 ± 0.02 [e]	0.55 ± 0.00 [d]	0.33 ± 0.00 [e]
5	438.46 ± 3.14 [f]	21.99 ± 0.13 [e]	43.60 ± 0.26 [e]	2.11 ± 0.02 [f]	0.59 ± 0.00 [e]	0.36 ± 0.00 [f]
6	530.73 ± 5.80 [g]	23.30 ± 0.23 [f]	49.01 ± 0.67 [f]	2.30 ± 0.01 [g]	0.67 ± 0.01 [f]	0.39 ± 0.00 [g]
7	620.76 ± 5.21 [h]	24.39 ± 0.06 [g]	53.20 ± 0.46 [g]	2.57 ± 0.02 [h]	0.69 ± 0.01 [g]	0.43 ± 0.00 [h]

Results are shown as average value ± standard deviation of six replications. [a–h] Different letters in superscript of the same table column indicate the statistically significant difference between values at a level of significance of $p < 0.05$ (based on post-hoc Tukey HSD test).

3.7. Antioxidant Activity of Cookies

Total phenolic content and antioxidant activity of cookies incorporated with celery root dehydrated by the combined method were determined by two different methods (DPPH and ABTS) and are present in Table 8. As the level of celery powder in the cookie samples increased from 5 to 30%, the values of TPC, DPPH and ABTS radical-scavenging activity statistically significantly ($p < 0.05$) increased. These results indicate that addition of combinedly dehydrated celery root powder could be an effective way to enhance the antioxidant activity of the cookies. The control sample contained 6.42 mg GAE/100 g phenolic content, and supplementation at levels of 5–30% statistically significantly increased this content by 8.17–46.57 times, respectively. The enhancement of cookies' TPC content can be attributed to the synergistic contribution of celery root and molasses, which are both reported to be rich in phenolic compounds. In addition, the results from both antioxidant activity determinations showed an increase in initial values from 0.6 (sample 1) to 50.84 µmol TE/100 g for DPPH and from 2.43 (sample 1) to 180.61 µmol TE/100 g for the ABTS method, via the maximum substitution level of wheat flour with celery powder. Similar to the presented results, many authors have found that the addition of materials rich in phenols and other bioactive compounds led to an improvement in the antioxidant properties of the final products [42,47,48].

Table 8. Cookie samples' phenol content and antioxidant activity.

Sample No:	Total Phenolic Content (mg GAE/100 g d.m.)	Antioxidant Activity by DPPH (µmol TE/100 g d.m.)	Antioxidant Activity by ABTS (µmol TE/100 g d.m.)
1	6.42 ± 0.04 [a]	0.60 ± 0.00 [a]	2.43 ± 0.02 [a]
2	52.46 ± 0.49 [b]	8.57 ± 0.04 [b]	32.44 ± 0.28 [b]
3	97.82 ± 1.15 [c]	17.17 ± 0.12 [c]	60.46 ± 0.29 [d]
4	141.69 ± 0.72 [d]	26.10 ± 0.28 [d]	90.73 ± 0.51 [e]
5	189.41 ± 2.54 [f]	33.97 ± 0.12 [f]	119.71 ± 1.02 [g]
6	234.76 ± 1.95 [g]	42.47 ± 0.12 [g]	153.76 ± 1.63 [h]
7	299.46 ± 2.02 [h]	50.84 ± 0.35 [h]	180.61 ± 1.95 [i]

Results are shown as average value ± standard deviation of six replications. [a–i] Different letters in superscript of the same table column indicate the statistically significant difference between values at a level of significance of $p < 0.05$ (based on post-hoc Tukey HSD test).

3.8. Optimization of Celery Powder Addition

Z-score analysis was applied in an effort to define the optimal quantity of osmodehydrated and lyophilized celery root powder added to the cookies' formulation from the aspect of all combined quality characteristics. The change in individual quality characteristics with the celery root powder addition can be observed by analyzing segment Z-score values (from S_1 to S_7), where it can be seen that maximal Z-score values for technological quality, textural analysis, instrumental color analysis and descriptive sensory analysis (S_1–S_4) were obtained for the cookie sample without the addition of celery root powder (Figure 1). Maximal Z-score values for chemical composition, mineral matter and phenol content and antioxidant activity (S_5–S_7), however, were obtained for the cookie sample with the addition of the maximal quantity of celery root powder.

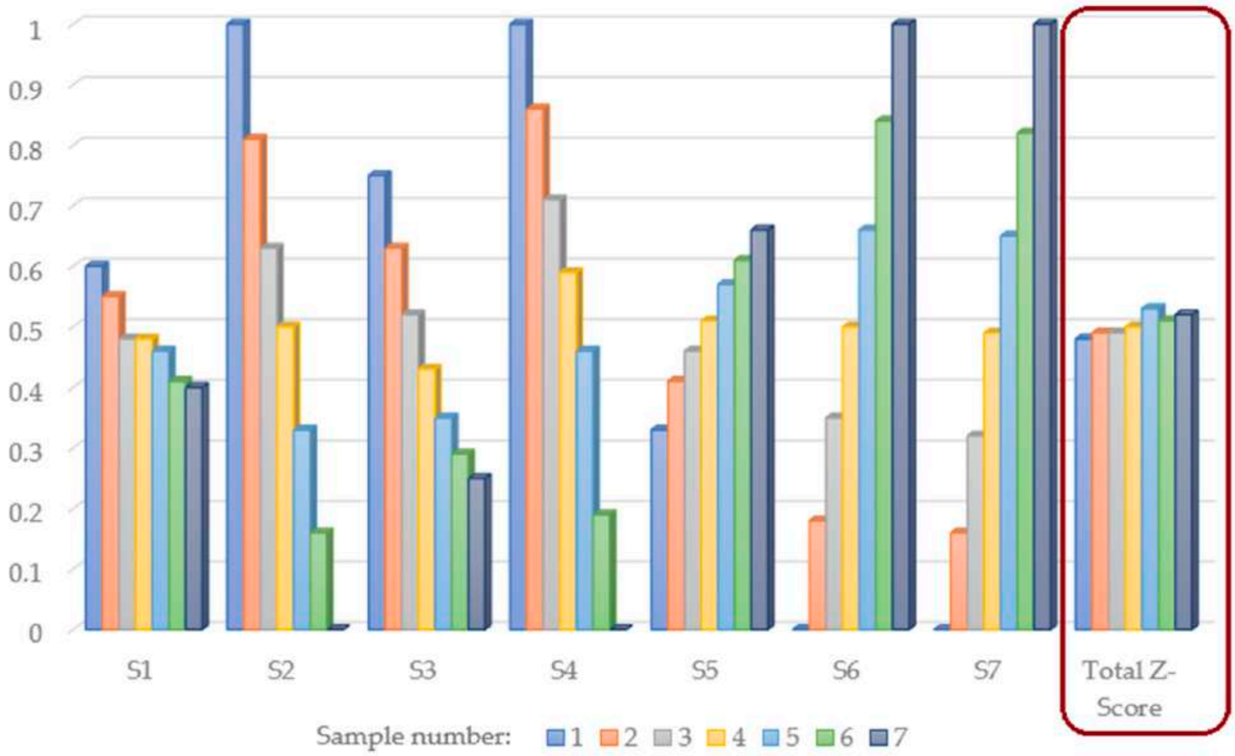

Figure 1. Z-score analysis of cookies with and without the addition of osmodehydrated and lyophilized celery root.

Total Z-score values mathematically combine all tested quality characteristics in the following manner: 15%, 5%, 10%, 20%, 20%, 20% and 10% of technological quality, textural analysis, instrumental color analysis, descriptive sensory analysis, chemical composition, mineral matter, phenol content and antioxidant activity contribution to the total cookies' quality, respectively. Maximal obtained total Z-score value, with the value of 53.13%, marked cookie sample number 5 (20% of osmodehydrated and lyophilized celery root powder substitution for wheat flour in the cookie's formulation) as the cookie sample with the maximal total quality, hence marking the amount used in this sample as the optimal quantity of celery root powder substitution.

The obtained results of optimization directed the additional research direction and defined the second research phase—evaluation of the combined osmodehydration and lyophilization method of dehydrating celery root via comparison to the more conventional dehydration methods of convective dehydration and lyophilization and their application to the cookies' formulation. For the evaluation of wheat flour substitution with the celery root powder obtained by the combined osmodehydration and lyophilization method on the cookies' quality characteristics, the amount of 20% of wheat flour substitution with the celery root powder was chosen, and cookies with the same amount of wheat flour substitution but with differently dehydrated celery root powder were compared.

3.9. The Influence of Dehydration Method of Celery on Technological and Nutritional Quality of Cookies

The addition of the same amount of celery powder (20%) obtained by different dehydration methods resulted in higher values for baking and drying weight loss in samples 8 and 9 (celery root dehydrated by convective and lyophilization methods) compared to sample 5 (dehydrated by the combined method), although these values are not statistically significantly different (Table 9). The lowest BWL and DWL parameters in sample 5 could be elucidated by the fact that the added celery powder in this cookie formulation also contains a certain amount of molasses, which penetrated into the celery tissue via secondary mass transfer during osmotic pre-treatment, and since it has known humectant properties, it can thereby affect water retention in the final product [45,50]. Results from Table 9 showed that with the same addition level of celery root powder in samples 5, 8 and 9, there were no statistically significant differences in the values of the thickness and diameter, indicating that the celery root dehydration method did not have a significant effect on the cookies' dimensions. Slightly higher thickness and lower diameter, however, were observed in sample 5, with celery powder produced by the combined dehydration method. The influence of the dehydration method shows that the cookie sample with celery dehydrated by the convective drying (8) had a statistically insignificantly higher shape deformation compared to cookies with celery dehydrated by the combined method and lyophilization. Hence, the differences in the values of the R/T ratio of samples 5, 8 and 9 are not expressed to a great extent and do not deviate much from the value for the control sample (1), which indicates that the celery root is well-dried and pulverized at the level of flour particles, and it is well incorporated into the dough structure. Considering that it is preferable that the values of BWL, DWL, R and R/T are lower, while T is higher, it is worth noting that the addition of celery root dehydrated by a combined method, including osmotic pre-treatment in molasses, had a more positive effect on the cookies' technological quality than the addition of celery root dehydrated by convective and lyophilization procedures.

From Table 9, it can be seen that samples 8 and 9 have higher hardness values compared to sample 5, although the differences were not statistically significant. These results indicated that osmotically pre-treated and successively lyophilized celery root affected the softer texture of cookies compared to celery root dehydrated by lyophilization and convective methods. Molasses, which is used as a medium for osmotic treatment during this process, diffused into the celery tissue, enriching it with its content. Although the same amount of powder is incorporated in samples 5, 8 and 9, in sample 5, the cellulose content is lower, considering that molasses does not contain cellulose. There is a possible explanation for the fact that the sample with celery root dehydrated by the combined method showed the lowest hardness, as it was previously mentioned that the higher fiber content leads to higher hardness and fracturability of cookies. The values showing fracturability of cookies did not differ statistically significantly depending on the type of celery drying. Cookie sample 8, containing celery powder obtained by convective drying, showcased the highest hardness and fracturability values.

When comparing cookies with 20% celery root powder dehydrated by different methods, the brightness parameter of the sample was not statistically significantly different for samples with celery dried by combined and convective methods (samples 5 and 8). It was even shown that the cookie with convectively dried celery was darker than the cookie with combined dried celery, where the darker coloring partly comes from molasses. This outcome is consistent with the findings of Galla et al. [25], where darkness increased with increased content of convectively dried spinach powder content in cookies, due to the browning of spinach carbohydrates during baking. On the other hand, the cookie containing lyophilized celery root powder showed an increase in the brightness parameter. Sample 9 was even lighter than the control sample (Table 4), which indicated that this dehydration technique is successful in maintaining the color of the celery root and affects in a positive manner the final product color. The share of red tone (a values) did not differ significantly between cookie samples fortified with combined and convectively dehydrated celery root, but the a values of both samples were increased when compared to the control cookie. However, the cookie with convectively dehydrated celery root powder has a slightly more pronounced redness. Compared to samples 5 and 8, sample 9 showed a statistically significantly lower proportion of red tone, a somewhat lower value compared to the control sample. In terms of yellow tone, cookies with convectively and combinedly dehydrated celery root showed lower values, while the cookie with lyophilized powder had a higher value, even compared to the cookie without celery (sample 1). Compared to the cookie containing combined dried celery, the cookie containing convectively dried celery exerted higher yellowness. Similar to the presented results, Mitrevski et al. [47] demonstrated that biscuits produced by substituting 15%, 20% and 25% spelt flour with convectively dried beetroot powder showed increases in L and a coordinate values and a decrease in the b coordinate value compared to the control sample without beetroot. The value of the parameter that indicates the variation in color in relation to the cookie with the standard formulation was the highest in sample 5 (ΔE = 17.84), slightly lower in sample 8 (ΔE = 13.60) and the least expressed in cookie 9 (ΔE = 6.63), from where the impact of incorporated molasses in the cookies' composition on its color change is evident.

Sensory analysis revealed that the color intensity was the highest in the sample enriched with combinedly dehydrated celery root powder, while the sample with convectively dried powder received a similar grade, only slightly lower. The sample with lyophilized powder received the lowest score for color intensity, close to the color intensity of the control sample. These results of subjective cookie evaluations were in accordance with previously reported results of instrumentally detected color parameters. Celery root powder produced by the combined dehydration method caused the higher value of the cookie's surface appearance descriptor compared to the convectively dried and lyophilized celery root at the same addition level. By observing the influence of the celery drying method on the final taste and smell of biscuits with 20% addition of dehydrated powder, it can be seen that the sample with combinedly dehydrated celery root deviated moderately (grade 3.3 for taste and grade 3.5 for odor) from the optimal descriptors set to value 4. This observation is similar to the findings of the sensory evaluation performed by Pestorić et al. [43], Shuchi et al. [51], Thorat et al. [48], Kajal et al. [52] and Sowmya et al. [40], who all reported that herbal cookies had acceptable sensory attributes. The most pronounced deviation from the standard taste and smell of cookies was characterized in the sample fortified with convectively dried powder (grades 6.5 and 6.3, respectively), followed by the sample enriched with lyophilized celery (grades 6.3 and 6.1, respectively). In sample 8, the burnt notes were more pronounced, and in sample 9, notes originating from celery were more pronounced. These results are consistent with Deepali and Roji [42], who claimed that coriander-fortified biscuits had a lesser score in appearance, aroma, texture, taste and overall acceptability than the control biscuits without any fortification.

The highest sensory hardness and fracturability was shown by the cookie with the addition of convectively dried celery root, the lowest hardness was in the cookie with the combinedly dehydrated celery root and the lowest fracturability was seen in the cookie with lyophilized celery root. These results obtained in sensory evaluation correlated with instrumental analysis of texture, indicating subjectively measurable differences in cookies' texture depending on the type of celery root powder addition.

The influence of the dehydration technique on celery root, which was used as a substitute for wheat flour in the optimal amount of 20% at the final chemical composition of the cookies, is shown in Table 9. The results indicate that the dehydration method of celery root had no statistically significant effect on the contents of fat and starch in tested cookie samples. On the other hand, the cookie with celery powder previously osmodehydrated in molasses had a higher protein content and higher total sugar and ash contents compared to cookies with celery that was convectively and freeze-dried. It was evident that the higher cookie contents of protein and especially total sugars and ash can be attributed to molasses containing large amounts of sugar (over 50%) and minerals [50]. In terms of cellulose content, it is obvious that samples with the addition of convective and lyophilized celery powder showed higher proportions, because celery is a cellulose-rich material, while molasses does not contain cellulose [53].

Table 9. Cookie samples' quality.

Sample No:	Technological Quality Responses: BWL (%)	DWL (%)	T (mm)	R (mm)	R/T	Textural Analysis Responses: Hardness (n)	Fracturability (mm)	Instrumental Color Analysis Responses: L	a	B	ΔE
5 *	17.00 ± 0.46 ^{ab}	0.65 ± 0.04 ^{bc}	48.42 ± 0.49 ^{bc}	99.73 ± 0.38 $^{b-d}$	2.06 ± 0.01 ^{d}	3923.50 ± 300.53 ^{cd}	2.49 ± 0.16 $^{c-e}$	41.98 ± 0.37 ^{b}	8.99 ± 0.57 ^{de}	14.83 ± 0.30 ^{b}	17.84 ± 0.62 ^{e}
8	17.53 ± 0.84 $^{a-c}$	0.69 ± 0.09 $^{b-d}$	48.05 ± 0.29 ^{bc}	100.21 ± 0.67 $^{b-d}$	2.09 ± 0.00 ^{d}	4713.87 ± 155.54 ^{de}	2.57 ± 0.26 $^{c-e}$	45.06 ± 0.25 ^{c}	9.46 ± 0.47 ^{e}	18.93 ± 0.33 ^{d}	13.60 ± 0.77 ^{d}
9	17.18 ± 0.19 ^{ab}	0.67 ± 0.04 $^{b-d}$	48.11 ± 0.41 ^{bc}	99.83 ± 0.48 $^{b-d}$	2.08 ± 0.00 ^{d}	4343.45 ± 691.20 $^{c-e}$	2.43 ± 0.10 $^{c-e}$	64.34 ± 1.44 ^{g}	6.07 ± 0.10 ^{a}	23.55 ± 0.72 ^{f}	6.63 ± 0.48 ^{b}

Sample No:	Descriptive Sensory Analysis Responses: Color Intensity	Surface Appearance	Taste	Odor	Hardness	Fractur-ability	Chemical Composition Responses: Proteins (% d.m.)	Starch (% d.m.)	Total Sugars (% d.m.)	Cellulose (% d.m.)	Lipids (% d.m.)	Ash (% d.m.)
5 *	5.6 ± 0.2 ^{ef}	3.5 ± 0.4 ^{bc}	3.3 ± 0.5 ^{b}	3.5 ± 0.4 ^{c}	5.0 ± 0.5 ^{cd}	6.1 ± 0.1 ^{cd}	9.67 ± 0.07 ^{c}	38.06 ± 0.39 ^{c}	6.84 ± 0.04 ^{f}	0.59 ± 0.01 ^{a}	18.43 ± 0.21 ^{c}	1.35 ± 0.01 ^{f}
8	5.0 ± 0.2 ^{de}	5.0 ± 0.0 ^{de}	6.5 ± 0.4 ^{c}	6.3 ± 0.0 ^{d}	5.3 ± 0.8 ^{cd}	6.4 ± 0.6 ^{cd}	8.84 ± 0.12 ^{a}	38.03 ± 0.63 ^{c}	2.78 ± 0.02 ^{b}	0.79 ± 0.01 ^{b}	18.53 ± 0.10 ^{c}	0.49 ± 0.01 ^{b}
9	3.3 ± 0.3 ^{a}	5.6 ± 0.3 ^{e}	6.3 ± 0.3 ^{c}	6.1 ± 0.2 ^{d}	5.2 ± 0.7 ^{cd}	5.9 ± 0.2 ^{c}	8.95 ± 0.09 ^{ab}	38.09 ± 0.42 ^{c}	2.81 ± 0.01 ^{b}	0.82 ± 0.01 ^{c}	18.47 ± 0.06 ^{c}	0.48 ± 0.00 ^{b}

Sample No:	Mineral Content Responses: K (mg/100 g d.m.)	Mg (mg/100 g d.m.)	Ca (mg/100 g d.m.)	Fe (mg/100 g d.m.)	Zn (mg/100 g d.m.)	Cu (mg/100 g d.m.)	Phenol Content and Antioxidative Activity Responses: Total Phenolic Content (mg GAE/100 g d.m.)	Antioxidative Activity by DPPH (μmol TE/100 g d.m.)	Antioxidative Activity by ABTS (μmol TE/100 g d.m.)
5 *	438.46 ± 3.14 ^{f}	21.99 ± 0.13 ^{e}	43.60 ± 0.26 ^{e}	2.11 ± 0.02 ^{f}	0.59 ± 0.00 ^{e}	0.36 ± 0.00 ^{f}	189.41 ± 2.54 ^{f}	33.97 ± 0.12 ^{f}	119.71 ± 1.02 ^{g}
8	135.46 ± 0.29 ^{b}	18.24 ± 0.11 ^{b}	34.01 ± 0.17 ^{c}	1.13 ± 0.01 ^{a}	0.48 ± 0.00 ^{b}	0.27 ± 0.00 ^{c}	51.76 ± 0.49 ^{b}	8.43 ± 0.06 ^{b}	35.70 ± 0.32 ^{c}
9	134.13 ± 1.75 ^{b}	18.23 ± 0.09 ^{b}	34.15 ± 0.17 ^{c}	1.14 ± 0.01 ^{a}	0.49 ± 0.01 ^{b}	0.29 ± 0.00 ^{d}	170.94 ± 0.88 ^{e}	29.73 ± 0.22 ^{e}	115.09 ± 0.82 ^{f}

* Response values for sample 5 are repeatedly shown in Table 9. for easier comparison with the response values of samples 8 and 9. $^{a-g}$ Different letters in superscript of the same table column indicate the statistically significant difference between values at a level of significance of $p < 0.05$ (based on post-hoc Tukey HSD test).

The data from Table 9 revealed that the cookie with 20% celery root powder osmotically pre-treated in molasses had statistically significant higher contents of all analyzed mineral matters. The mineral contents of cookies with the same addition of convective and lyophilized celery root powder did not differ statistically significantly. In comparison with the control cookie (Table 7), these samples (8 and 9) showed about 49% higher potassium content, 8.6% higher magnesium content, 39% higher calcium content, 25% higher zinc content and 16% higher copper content, with an exception for iron, where 6% lower content was recorded. The increase in the contents of K, Mg, Ca, Zn and Cu in cookies indicates that celery is a good source of these minerals. In celery root, Krešić et al. [10] reported 308 mg/100 g of potassium and 73 mg/100 g of calcium, while Golubkina et al. [2] demonstrated quantities of 4.7 mg/100 g of iron, 0.5 mg/100 g of copper and 0.7 mg/100 g of zinc. Sample 5, containing celery powder enriched with molasses, gained 383.79% higher potassium content, 30.97% higher magnesium content, 77.76% higher calcium content, 75.8% more iron, 51.28% higher zinc content and 33.33% more copper than the control cookie. The explanation for the greatly improved mineral status can be found in the literature, which confirms that sugar beet molasses is a powerful source of minerals. The dominant macroelement is potassium, which quantitatively accumulates in the molasses during industrial sugar production and varies in amount from 2190 to 6000 mg/100 g, while the dominant microelement is iron, which can vary in the range from 2.7 to 11.7 mg/100 g [16,50]. Mordenti et al. [54] reported that sugar beet molasses contains 70 mg/100 g of calcium, 50 mg/100 g of magnesium, 1.3 mg/100 g of copper and 0.7 mg/100 g of zinc.

Comparison of the samples with the same level of celery root powder incorporation but dehydrated by different methods indicated statistically significantly different TPC, DPPH and ABTS values for all three observed samples. As seen from the data in Table 9, the cookie containing celery powder previously osmotically dehydrated in molasses had 10.8% higher content of total phenols, 14% higher antioxidant activity determined by the DPPH method and 4.01% higher antioxidant activity determined by the ABTS method in relation to the cookie with only lyophilized celery powder. The process of lyophilization has been rated by other authors as relatively successful in preserving antioxidant and phenolic components [11,12], so the higher values of the parameters describing the antioxidant potential of cookie sample 5 most likely come from molasses, which distinguishes the compositions of samples 5 and 9. In the research by Filipčev et al. [50] and Chen et al. [55], sugar beet molasses is characterized as a raw material with excellent antioxidant properties. Conversely, sample 8 prepared by the addition of convectively dried celery root in the formulation had distinctly lower total phenolic content and antioxidant activity as determined by both methods as compared to samples 5 and 9. Sorouret al. [56] analyzed the effect of convective drying at T = 70 °C and T = 90 °C on the concentration of phenols in celery, and significant loss of total phenols was found, especially at higher drying temperatures, which is consistent with the presented results. Salamatullah et al. [57] revealed that after heat treatment, the phenol content in 100 g celeriac decreased from 22.2 mg GAE in the control to 3.0 mg GAE. Ramachandraiah and Chin [58] also proved the loss of celery root phenol content after applying convective drying at T = 50, 70 and 100 °C. Marić et al. [11], in their study, confirmed that lyophilization was a more effective method in retaining the antioxidant activity in carrots compared to convective drying. After drying at T = 50 °C, total phenolic content in carrots was reduced by approximately 50% and after drying at T = 70 °C by approximately 75% in relation to the fresh sample. Kręcisz et al. [9] reported the effect of dehydration methods on the content of bioactive compounds in fresh celery root in the following way: TPC 143.43 mg GAE/100 g d.m.; DPPH 386.01 µmol TE/100 g d.m.; ABTS 721.53 µmol TE/100 g d.m for freeze drying and TPC 128.29 mg GAE/100 g d.m.; DPPH 222.48 µmol TE/100 g d.m.; and ABTS 624.41 µmol TE/100 g d.m for convective drying.

3.10. PCA

The ability of PCA to decrease the number of parameters involved in complex systems was used to simplify the correlation structure [59] between 32 responses of technological quality; textural, instrumental color and descriptive sensory analysis; chemical and mineral matter composition; and phenol content and antioxidant activity and all nine cookie samples produced and tested in this research. In an effort for data trends visualization and applied descriptors discriminating efficiency, a scatter plot was made, showcasing the first two principal components of the data matrix. At the x-axis and y-axis, the first and second principal components are placed, respectively, as seen in Figure 2.

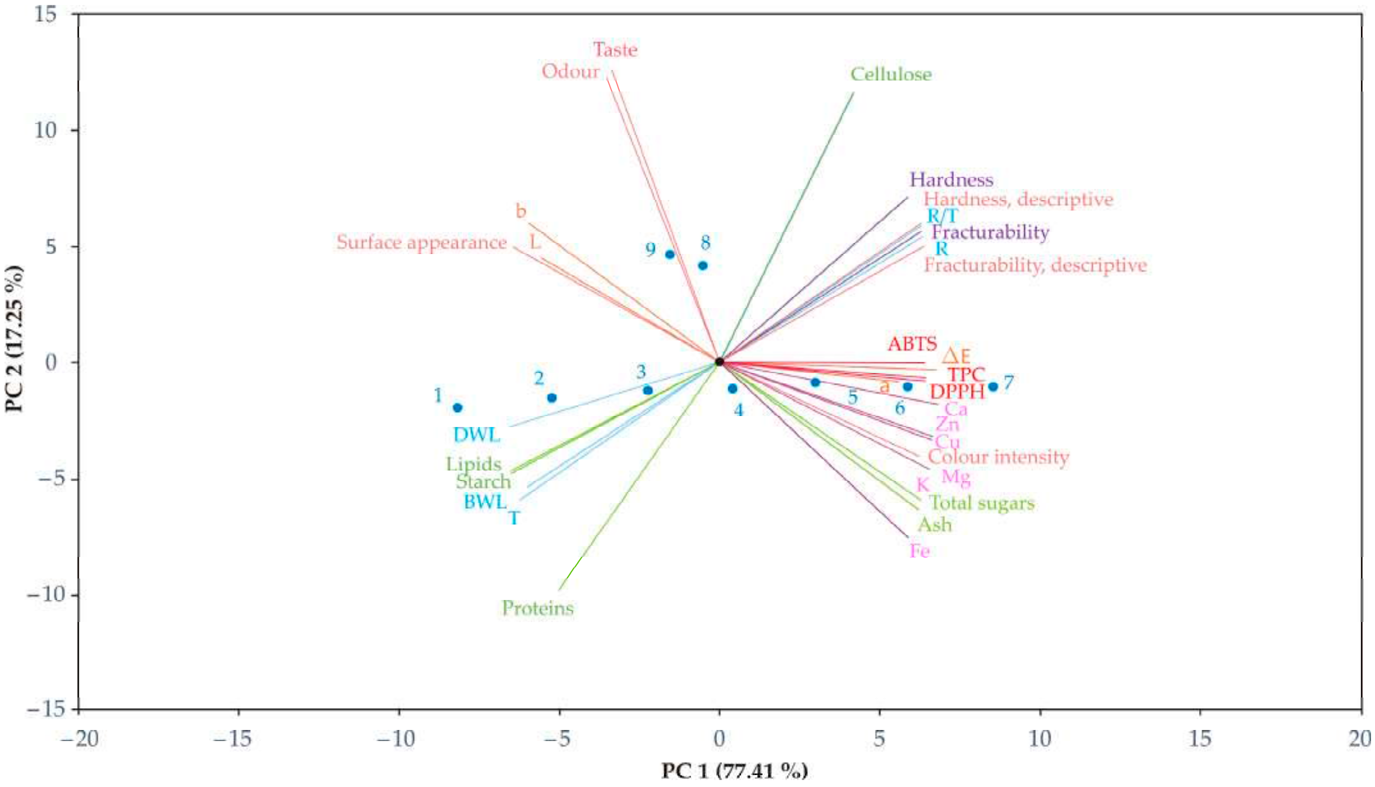

Figure 2. PCA of the tested cookies, with and without the celery root powder substitution.

From the scatter plot, it can be visually determined that the separation of all tested cookie samples is significant, since they are characterized by different quality responses. By observing the set of cookie samples with the same type of celery root powder addition (samples 1 to 5), it can be seen that the increasing quantity of celery root powder addition affected the transition from negative first principal component values to positive values, without affecting the significant shift in second principal component values, between samples.

Addition of celery root powder dehydrated by convective dehydration and lyophilization to the cookie recipes (samples 8 and 9) caused their location shift to higher second principal component values in comparison to samples with the addition of osmodehydrated and lyophilized celery root powder.

Cookie samples without (sample 1) and with the addition of small quantities of osmodehydrated and lyophilized celery root powder (samples 2 and 3) were characterized by high values of technological characteristics responses; lipid, starch and protein content; surface appearance and lightness. Cookie samples with the addition of more significant quantities of osmodehydrated and lyophilized celery root powder (samples 4–7) were characterized by higher values of all mineral content responses, phenolic content and antioxidant activity, ash and total sugar content and instrumental and descriptive sensory hardness and fracturability.

Cookie samples with the addition of celery root powder dehydrated by convective dehydration and lyophilization were differentiated on the basis of higher values of odor and taste responses.

Analysis of the method quality showed that the first two principal components accounted for 94.66% of the total variance, indicating that the given data description is significant.

All tested responses except taste, odor and cellulose significantly contributed to the first principal component. On the other hand, previously mentioned exceptions significantly contributed to the second principal component.

3.11. Evaluation of the Overall Quality of the Cookies with Celery Root Powder Addition

Z-score analysis was applied again, but in this case with the goal of evaluating the quality characteristics of the cookies with the addition of osmodehydrated and lyophilized celery root powder (sample 5) in comparison to the quality of the cookies with the addition of celery root powder dehydrated by more conventional methods of convective dehydration and lyophilization (samples 8 and 9, respectively).

Analysis of segment Z-score values, in Figure 3, showed that sample 5 was characterized by the highest values for technological quality, textural analysis, chemical composition, mineral matter and phenol content and antioxidant activity, while sample 9 was marked with the highest scores for instrumental color analysis and descriptive sensory analysis. Total Z-score, which mathematically combined segment quality characteristics in the same manner as in the case of the previous Z-score analysis of the quantity of celery root powder addition optimization, showed significant differences between cookies' quality characteristics. The cookie sample with the addition of osmodehydrated and lyophilized celery root powder had total quality characteristics that were 28.85 percentile points higher than the cookie sample with the addition of lyophilized celery root powder and 65.24 percentile points higher than the cookie sample with the addition of convective celery root powder.

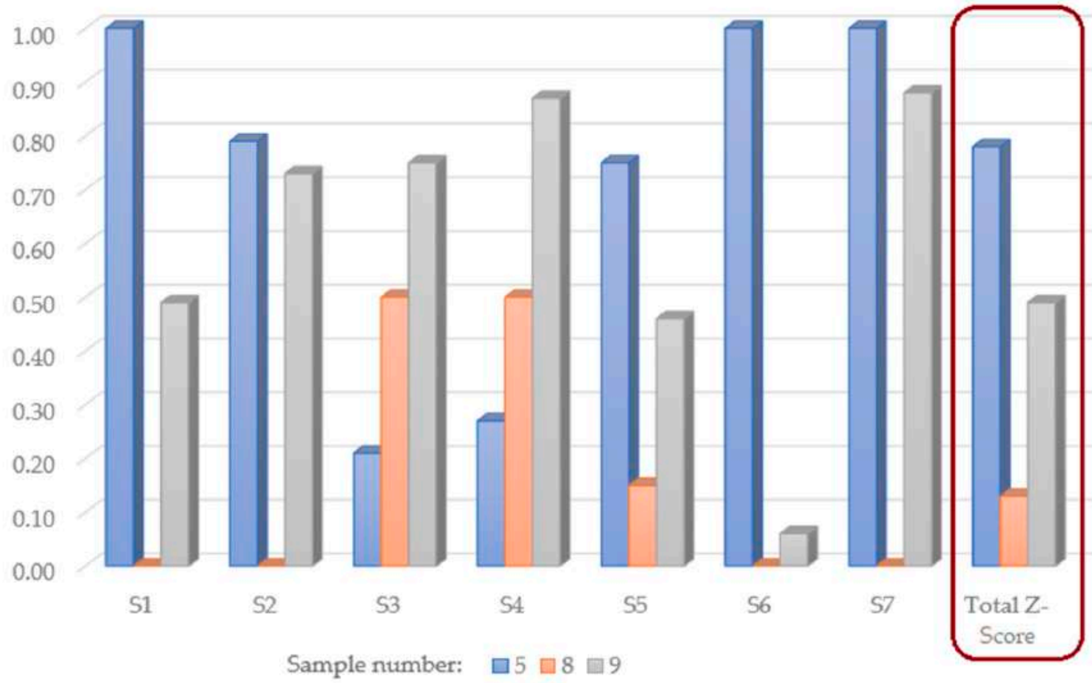

Figure 3. Z-score analysis of cookies with the addition of celery root dehydrated by different treatments.

4. Conclusions

The results revealed that an increase in the addition of combinedly dehydrated celery root powder in cookies led to decreases in weight reduction during baking and drying;

thickness; brightness; yellowness; standard taste and odor; surface appearance; and protein, starch and fat content but increases in average diameter, shape deformation, redness, color variation, color intensity, sensory hardness and fracturability, total sugars, cellulose and ash content, mineral and phenolic content and antioxidant activity as determined by DPPH and ABTS methods. The cookie with the 20% osmodehydrated and lyophilized celery root powder addition with a maximal Z-score value of 53.13% represented the cookie sample with the maximum overall quality and therefore the optimal amount of wheat flour substitution in the cookie formulation.

Considering the influence of the celery root dehydration type on the nutritional and technological quality of cookies with the same substitution level of wheat flour with dried powder, the combined method proved to be more effective than the convective and lyophilization methods. The cookie with celery root powder previously osmodehydrated in molasses had even higher contents of analyzed minerals, protein, total sugar and ash and total phenols and antioxidant activities compared to the cookie with lyophilized powder, although lyophilization is considered one of the best drying methods in terms of preserving nutritional and bioactive compounds. It is worth pointing out that combined drying, which implied pre-treatment in molasses and shortened lyophilization, in addition to affecting the improvement of the final product quality, also has environmental, energy and economic advantages.

Further research should be focused on finalizing the cookie recipe in terms of optimizing other ingredients, besides the wheat flour, as well as testing its acceptability for a wider consumer population and the possibility of market placement.

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2024.

NUTRITIONAL FOOD VALUE AND NUTRITIONAL QUALITY

LEGAL ASPECTS OF HEALTHY SAFE FOOD PRODUCTS PROTECTION

ECOLOGICAL MODELS AND SOFTWARE IN THE PRODUCTION OF HEALTHY SAFE FOOD

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CONSUMER ACCEPTABILITY EVALUATION OF NEW COOKIE TYPE WITH DEHYDRATED CELERY ROOT ADDITION

Abstract

In the research, a newly formulated cookie product with a 20% substitution of wheat flour with osmodehydrated and lyophilized celery root was produced in order to test its' consumers' acceptability. The cookie samples colour, taste and odour were widely accepted among a group of 427 randomly selected consumers. Younger consumers with lower educational and income levels scored the price of new product to be moderately important, but still a significant factor when making a purchase decision. The obtained results from the proposed new cookie product indicate the high potential for market success.

Key words: cookies, celery root, consumer acceptability, osmotic dehydration, lyophilization, sugar beet molasses,

INTRODUCTION

Celery root (*Apium graveolens* L.), contains many compounds beneficial to health, including dietary fibers, minerals, numerous vitamins and essential oils (Goldewska et al., 2020), but due to its specific organoleptic properties, celery root is mainly consumed as a vegetable or as a spice in cooking in the daily diet, while its use as an ingredient in food products is limited (Kręcisz et al., 2023).

The cookies, widely popularized food product, are traditionally produced from wheat flour. With a high percentage of fat and carbohydrates and a small amount of dietary fiber, minerals and other functional components, are good candidate for the production of upgraded-quality food via the addition of dehydrated vegetable products (Pinto et al., 2023).

Vegetable products can be dehydrated by different methods, each with its own advantages and disadvantages, while using the combined dehydration method presented by Filipović et al. (2022a), which includes low-energy osmotic pretreatment in molasses and abbreviated successive procedure of high-energy demanding lyophilization, dehydrate raw material in an economical and energy-enhanced way while enriching it with valuable nutrients from molasses.

The addition of dehydrated celery root to the cookies standard dough formulation affects the final sensory and textural properties of the newly formulated cookie, and it is necessary to carefully select and optimize the amount of ingredients in order to meet consumer expectations (Galla et al., 2017).

Optimized new type of cookie product, regardless of its nutritive enrichment, is uncertain how it will be accepted among consumers. Therefore, consumers' acceptance of products is recognized as a critical feature during functional product positioning (Filipović et al., 2022b).

The goal of this research is to test the consumer acceptability of a newly formulated cookie product with 20% substitution of wheat flour with osmodehydrated and lyophilized celery root, as a final validation of the new cookie product.

MATERIAL AND METHODS

Material

Fresh celery roots (*Apium graveolens* L. var. rapaceum, Alabaster variety) were acquired at the local green grocery in Novi Sad (Serbia). Sugar beet molasses, used as an osmotic solution in the osmotic pretreatment, was obtained from a sugar factory in Crvenka, Serbia. The following material was used for the preparation of cookies: white wheat flour, type T-400 produced by "Danubius", Novi Sad, Serbia; margarine produced by "AD Dijamant", Zrenjanin, Serbia; sugar produced by "Šajkaška" Žabalj, Serbia; NaCl produced by "SO Produkt", Stara Pazova, Serbia and $NaHCO_3$, produced by "Aleva", Novi Kneževac, Serbia.

Combined method of dehydration

The combined method of celery root dehydration was done in two phases. First, the process of osmotic dehydration in molasses, where fresh celery root was initially washed with running tap water, dried with paper towels, peeled and cut into cubes of approximately: 1 cm x 1 cm x 1 cm. Then, the celery cubes were immersed in vessels filled with molasses of the concentration of 85.04%, in quantity to obtain dehydrating material to osmotic solution ratio of 1:5. The osmotic dehydration process took place for 5 hours at atmospheric pressure in a thermostatic chamber (Memmert IN160, Schwabach, Germany) where the temperature was set and maintained at 20°C, with the manual stirring of the dehydrating samples and molasses every 15 minutes. After 5 hours, the osmotically treated celery samples were separated from the molasses, washed with running water to remove excess solution on the surface of the cubes and then blotted with paper towels to remove excessive water. Obtained osmotically dehydrated celery samples for the second phase, were frozen and stored at -30°C for 24h, and then subjected to the lyophilization process, using device: Christ ALPHA1-2 LDPLUS (Osterode am Harz, Germany). The lyophilization parameters were set at: a pressure of 1.6 Pa, a condenser temperature of -57°C and a process duration of 24h. After lyophilization, dehydrated samples were finely ground and sifted into a powder of uniform particle size, using a universal laboratory mill, type: WZ-1 (solem, ZBPP, Bydgszcz, Poland).

Cookie samples preparation

The following quantities of raw material needed for cookie samples' production were used: flour mixture: white wheat flour: 80%, osmodehydrated and lyophilized celery root: 20%; margarine: 28.44% on the flour mixture basis; sugar: 1% on the flour mixture basis; NaCl: 0.95% on the flour mixture basis; $NaHCO_3$: 1.12% on the flour mixture basis; and tap water: 22.22% on the flour mixture basis (AACC, 2000).

The cookie preparation included dough production operations such as: mixing, processing and baking in a pilot plant for bakery products of the Institute for Food Technology in Novi Sad, Serbia, in accordance with the AACC method 10–50 D (2000), as described by Šobot et al. (2019).

Consumer survey

The acceptability of new type of cookie samples with 20% of dehydrated celery root substitution was assessed by a consumer survey. Based on the sample test, consumers answered the questions listed in Table 1.

In this research, cross-sectional data were collected from Serbia's Autonomous Province of Vojvodina. Cookie samples were given to 427 randomly selected consumers for testing, and the consumers were asked to provide answers to four general information and eight questions, including three general and five specific ones, formed according to Filipović et al. (2022b), as stated in Table 1.

Information regarding consumers' age, level of education, income level, and gender was also anonymously collected to analyze consumers' answers by different socio-economic parameters.

RESULTS AND DISCUSSION

Little is still known about the psychosocial factors influencing consumer attitudes toward choosing a new product on the market. Changes to the traditional dough composition for cookies' production can affect sensory properties in terms of colour, taste, and texture, which may influence consumer acceptance of the product. The quality and ratio of ingredients have a significant impact on the acceptance of the final product (Milner et al., 2020).

Table 1. Questions from the consumer questionnaire

Question type	Information/ Question no.	Information/Questions	Answer/Score
General information	I1	Consumer age	<18 y./18-30 y. /31-50 y./>51 y.
	I2	Education level	Primary school/ Secondary school/ College/ University
	I3	Income level	Low/Medium/ Higher/Highest
	I4	Gender	Male/Female
General questions	Q1	Do you read declaration on the cookies' packaging?	Answer: Yes/No
	Q2	Does your health condition require special diet?	
	Q3	Based on your opinion, does the diet type affects the health condition?	
Specific questions	Q4	Is the cookies' colour acceptable?	Score from: 1 to 9, 9 being the highest
	Q5	Is the cookies' taste acceptable?	
	Q6	Is the cookies' odour acceptable?	
	Q7	Is the cookies purchasing price an important reason for the purchase decision?	
	Q8	Would you by cookie with celery root addition and include it in regular diet?	

The first part of the results obtained from the consumers' questionnaire revealed the socio-demographic characteristics of consumers, regarding consumers' age, level of education, income level, and gender.

Consumers were divided into 4 age groups: 1. Teenagers (under 18 years of age) – 25 consumers, 2. Young people (18– 30 years of age) – 118 consumers, 3. Middle-aged people (31– 50 years of age) – 176 consumers and 4. Older people (over 50 years of age) – 108 consumers.

Consumers were divided into 4 groups based on the level of education: 1. Primary school – 22 consumers, 2. Secondary school – 124 consumers, 3. College – 48 consumers and 4. University – 233 consumers.

Consumers were divided into 4 groups based on income: 1. Low income – 96 consumers, 2. Medium income – 162 consumers. 3. Higher income – 127 consumers and 4. Highest income – 42 consumers.

Gender was divided into two groups: 1. Male - 210 consumers and 2. Female – 217 consumers.

Table 2 presents the processed results of consumer responses to the questionnaire questions, based on which it can be seen that with the increase in age, education level, and income level of consumers, there was also a statistically significant increase in the percentage of positive responses to the question about reading package labels. Younger respondents were not exposed to health problems that would require a special diet, which changes and increases with the increasing age of the respondents. In the general population surveyed, a small percentage of consumers (20.69%) have a health condition that requires a special diet. A large percentage of respondents in all groups answered positively to the question of whether, in their opinion, the type of diet affects health.

Table 2. Consumer answers to the questions from the questionnaire

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
		Share of positive answers (%)				Consumers score (average value ± standard deviation)			
Consumers' age	<18	10.24± 0.33^{a}	1.40± 0.03^{a}	74.61± 0.38^{a}	7.80± 0.12^{cd}	8.12± 0.08^{a}	7.86± 0.23^{de}	6.13± 0.10^{f}	4.86 ± 0.14^{a}
	18-30	43.16± 0.57^{c}	11.15± 0.25^{b}	91.05± 2.59^{e-g}	7.94± 0.07^{d}	8.05± 0.15^{a}	7.74± 0.01^{c-e}	4.33± 0.07^{b}	6.40 ± 0.02^{c}
	31-50	71.10± 0.69^{c}	27.46± 0.51^{i}	87.30± 1.32^{b-f}	7.25± 0.09^{a}	7.90± 0.18^{a}	7.52± 0.12^{a-d}	3.82± 0.05^{a}	7.91 ± 0.23^{h}
	>50	80.30± 1.05^{g}	34.09± 0.18^{k}	90.82± 0.47^{d-g}	7.64± 0.05^{b-d}	7.89± 0.07^{a}	7.30± 0.06^{ab}	5.15± 0.04^{d}	7.52 ± 0.24^{fg}
Education level	Elem.	34.19± 0.10^{b}	16.50± 0.23^{d}	84.30± 0.75^{b}	7.83± 0.09^{cd}	8.05± 0.13^{a}	7.91± 0.10^{e}	6.49± 0.09^{g}	6.14 ± 0.02^{bc}
	Middle	60.01± 1.61^{d}	18.15± 0.07^{c}	86.90± 1.76^{b-c}	7.90± 0.05^{d}	7.85± 0.08^{a}	7.31± 0.11^{ab}	5.81± 0.09^{c}	5.77 ± 0.10^{b}
	Higher	81.18± 0.76^{g}	25.99± 0.43^{h}	85.97± 1.19^{b-d}	7.90± 0.11^{d}	8.09± 0.21^{a}	7.15± 0.21^{a}	5.60± 0.06^{e}	6.80 ± 0.14^{d}
	High	80.15± 1.82^{g}	30.11± 0.74^{j}	93.10± 2.86^{g}	7.39± 0.08^{ab}	7.73± 0.24^{a}	7.51± 0.07^{a-d}	4.80± 0.12^{c}	7.66 ± 0.13^{gh}
Income level	Low	41.05± 0.99^{c}	20.11± 0.16^{f}	85.00± 0.78^{bc}	7.90± 0.08^{d}	8.09± 0.16^{a}	7.39± 0.11^{a-c}	5.10± 0.07^{d}	5.20 ± 0.07^{a}
	Medium	75.50± 1.38^{f}	19.49± 0.28^{f}	87.02± 2.20^{b-e}	7.75± 0.23^{cd}	8.01± 0.14^{a}	7.59± 0.12^{b-e}	4.86± 0.07^{c}	6.80 ± 0.10^{d}
	Higher	81.90± 1.32^{g}	15.60± 0.27^{d}	89.56± 2.24^{c-g}	7.50± 0.12^{a-c}	7.77± 0.06^{a}	7.62± 0.07^{b-c}	4.42± 0.04^{b}	6.30 ± 0.11^{c}
	The highest	79.90± 2.47^{g}	14.19± 0.29^{c}	92.30± 2.48^{fg}	7.41± 0.11^{ab}	7.97± 0.07^{a}	7.37± 0.11^{a-c}	3.96± 0.11^{a}	7.29 ± 0.03^{fg}
Gender	Male	60.10± 0.91^{d}	19.68± 0.49^{f}	86.70± 0.70^{b-c}	7.97± 0.11^{d}	7.97± 0.06^{a}	7.60± 0.18^{b-c}	4.80± 0.05^{c}	6.86 ± 0.18^{dc}
	Female	69.45± 1.05^{c}	21.93± 0.41^{g}	89.17± 0.74^{b-g}	7.80± 0.13^{cd}	8.02± 0.14^{a}	7.49± 0.08^{a-d}	5.29± 0.06^{d}	7.23 ± 0.03^{ef}
Total in all groups		64.31± 0.97	20.69± 0.45	87.81± 0.72	7.89± 0.12	7.99± 0.10	7.55± 0.14	5.02± 0.05	7.03± 0.11

$^{a-i}$ Different letters in superscript of the same table column indicate the statistically significant difference between values, at a level of significance of $p < 0.05$ (based on post-hoc Tukey HSD test)

The answers to specific questions about the acceptability of cookies' colour, taste, and smell with dehydrated celery (Q4-Q6) were very high (close to the maximum score of 9). The colour of the biscuits was highly rated by all consumers (from 7.25 to 7.94 of maximal 9), while somewhat lower ratings were recorded for middle-aged consumers with a high level of education and the highest income level. The difference between consumers' gender acceptability of the cookies' colour scores was statistically insignificant. The taste of the cookies was better rated by the younger, less educated, and less-income population. However, all scores were very similar, and very high (from 7.73 to 8.12 of maximal 9)– higher than the cookies' colour scores. As in the case of a previous specific question, female consumers gave statistically insignificantly higher scores for the cookies' taste, than male consumers. Responses to the cookies' odour scoring followed the same trends as in case of the cookies' taste scoring, in all tested consumer groups. Score values ranged from 7.15 to 7.86 of maximal 9.

The price of cookies with dehydrated celery root was rated moderate and marked as a more important parameter when purchasing in younger populations, with lower education and income levels. The answer to the last question, whether consumers would buy cookies with dehydrated celery root and include them in their regular diet, showed a high level of positive attitude towards the presented new product, among all tested consumers (average score between all groups of 7.03 of maximal 9). The older population, of higher education and income levels gave statistically significantly higher scores to this most important question regarding cookies acceptability. As in all previous cases, female consumers gave statistically insignificantly higher scores of cookies acceptability than male consumers.

CONCLUSION

From the presented results it can be concluded that consumers across all socio-demographic gropus were well aware of the significance of product declarations and the interaction between diet and health, though few had specific dietary needs. The newly proposed product's colour, taste and odour were widely accepted.

Results of consumers' acceptability evaluation showed high appreciation of cookies with dehydrated celery root sensory characteristics by large group (427) of randomly selected consumers. Consumers showed a high positive attitude towards presented new product and indicated on its' high potential for market acceptability.

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ИСПИТИВАЊЕ СТАВОВА ПОТРОШАЧА У ВЕЗИ НОВЕ ВРСТЕ КЕКС ПРОИЗВОДА СА ДОДАТКОМ ДЕХИДИРАНОГ КОРЕНА ЦЕЛЕРА

Апстракт

За потребе овог истраживања произведена је ново формулисана врста кекса са заменом 20% пшеничног брашна са осмотски дехидрираним и лиофилизованим кореном целера, како би се испитали ставови потрошача у вези његове прихватљивости. Боја, укус и мирис кекса били су широко прихваћени међу групом од 427 насумично одабраних потрошача. Млађи потрошачи, са нижим нивоом образовања и прихода, оценили су цену новог производа као умерено важну, али и даље као значајан фактор при доношењу одлуке о куповини. Добијени резултати за прихватљивост потрошача нове врсте производа кекса, указују на велики потенцијал за успех на тржишту.

Кључне речи: кекс, корен целера, ставови потрошача, осмотска дехидратација, лиофилизација, меласа шећерне репе.

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NUTRITIVE PROFILE EVALUATION OF THE CELERY DEHYDRATED BY DIFFERENT METHODS

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ABSTRACT

Celery (*Apium graveolens* L.) is an aromatic vegetable, a member of the Apiaceae family. Celery is a globally cultivated vegetable. Celery root is rich in dietary fibre, mineral elements, vitamins and essential oils and, as such, has health benefits. Celery root has few calories, it can be consumed raw or treated.There are different dehydration methods used to preserve plant material, such as convective, lyophilisation and combined dehydration methods. Convective dehydration is characterized by a high temperature which influences the sensory and nutritional characteristics of the product. The lyophilisation method preserves the nutritional and sensory characteristics of products, but it involves increased process costs and longer dehydration times. The combined dehydration method consists of osmotic dehydration in molasses and lyophilisation as a successive dehydration phase. This study aims to investigate the effect of different dehydration methods on the chemical and mineral composition of the celery root. The significant differences between different methods of draying of celery root are confirmed by the application of post-hoc Tukey's HSD test at a 95% confidence limit. The calculation of Z-Score Analysis, based on chemical and mineral parameters, points out the best score of celery root dehydration by the combined method, obtaining 91.67%, while celery lyophilisation and convective dehydration obtained only 15.67% and 7.60% of maximal score values, respectively.
Keywords: *dehydration methods, chemical composition, mineral composition, celery root*

INTRODUCTION

The *Apiaceae* family, also known as the *Umbelliferae* family, is a significant and diverse family of flowering plants. It encompasses approximately 3780 species distributed across 434 genera. This family is globally widespread, with members commonly found in tropical high-altitude regions and the northern temperate zones. Onions, celery, and kale are rich sources of various health-promoting compounds. Scientific research has highlighted several bioactive compounds in these vegetables, contributing to their health benefits, particularly their antioxidant properties. A good deal of scientific articles have found that onions, celery, and kale are good sources of health-promoting compounds, i.e. apiin, apigenin, rutin, oleic acid, pantothenic acid, α-linolenic acid, succinate, vitamin E (Liu et al, 2020) glycosides of quercetin, kaempferol, coumaric acid, ferulic acid, sinapic acid, coffee acid (Olsen, Aaby & Borge, 2009), and have high antioxidant capacity (Liu et al., 2020, Kręcisz et. al 2023).
Celery (*Apium graveolens* L.) is an aromatic vegetable, a member of the family Apiaceae. Celery is a globally cultivated vegetable with three botanical varieties: *var. Rapaceum*, known as 'celeriac' with a large root tuber (popular in Europe); *var dulce*, forming a crisp stalk (popular in the USA and Western Europe); and *var. secalinum* (Asia) (Bruznican, De Clercq, Eeckhaut, Van Huylenbroeck, & Geelen, 2020). Celery root which has low calories can be consumed either raw or cooked (Kian-Pour 2023). In recent times, there is a growing emphasis on enhancing the utilization of secondary products from the food industry, such as sugar beet molasses. These by-products are valuable sources of natural antioxidants, minerals, and other functional ingredients. They can be effectively used to enrich food

products, thereby increasing their nutritional value and contributing to more sustainable food production practices.

Besides changes in the attractiveness and quality of food after dehydration, another major disadvantage of dehydration in the food industry is its high cost (Baysan et al. 2024).

In every technological process, it is very important to accurately define the production parameters of the process to achieve a good and consistent product quality while minimizing the loss of nutritional and functional properties of the raw materials (Košutić 2016, Košutić et all 2016), where combined dehydration method of peach was characterized by upgraded overall dehydration effectiveness, reduced time and energy consumption, and enhanced chemical and mineral matter content of dehydrated peach samples (Filipović et al., 2022a), indicating the research path for the celery root dehydration.

This study aims to investigate the effect of different dehydration methods on the chemical and mineral composition of the celery root. The findings are expected to guide the food processing industry in selecting the best dehydration technique to produce high-quality dried celery root with maximum health benefits and desirable physical properties.

MATERIAL AND METHODS

Material

Fresh celery root (Apium graveolens L. var. rapaceum, Alabaster variety) was sourced from a local greengrocery in Novi Sad, Serbia. The celery root had an average dry matter content of 9.05%. Sugar beet molasses, used as an osmotic solution in the osmotic pre-treatment process, was obtained from a sugar factory in Crvenka, Serbia, and had an average dry matter content of 86.04%.

Convective Dehydration

Diced celery samples were subjected to convective dehydration using the following procedure: **Dehydration Process**: The samples were dried to a constant mass in a dryer (Instrumentaria, Zagreb, Croatia) set at 50°C (Kręcisz et al., 2023; Marić et al., 2020).

Grinding: Once dehydrated, the samples were pulverized using a universal laboratory mill, type: WZ-1 (solem, ZBPP, Bydgoszcz, Poland), to obtain convectively dried celery root powder.

Lyophilisation

Fresh samples of diced celery were processed using the following lyophilisation procedure:

Freezing: The diced celery samples were frozen for at least 24 hours at -30°C.

Lyophilisation: The frozen samples were placed on metal trays in a freeze-dryer (Christ ALPHA1-2 LDPLUS, Osterode am Harz, Germany). The lyophilisation parameters were set as follows: absolute pressure: 1.6 Pa, condenser temperature: -57°C, duration: 48 hours. Duration of the lyophilization process was determined on the basis of previous tests, where the chosen process duration produced dehydrated products without water content.

Grinding: After lyophilisation, the samples were ground using a universal laboratory milltype: WZ-1 (solem, ZBPP, Bydgoszcz, Poland).

Combined Method of Dehydration

The combined method of dehydrating celery root was executed in two stages: osmotic dehydration followed by lyophilisation. Here are the detailed steps:

Preparation of Celery Root: fresh celery root was washed with running tap water, dried with paper towels, peeled, and cut into cubes approximately 1 cm x 1 cm x 1 cm.

Osmotic Dehydration: the celery cubes were immersed in vessels filled with molasses (molasses content as described in Lončar et al., (2021)) at a ratio of 1:5 (dehydrating material to osmotic solution) to prevent excessive dilution of the molasses and slow down the process kinetics. This process took place over 5 hours at atmospheric pressure in a

thermostatic chamber (Memmert IN160, Schwabach, Germany), with the temperature set and maintained at 20°C.
Post-Osmotic Treatment: after 5 hours, the osmotically treated celery samples were separated from the molasses and washed with running water to remove excess solution from the surface of the cubes. The samples were then blotted with paper towels to remove excessive water.
Freezing: the osmotically dehydrated celery samples were frozen and stored at -30°C for 24 hours.
Lyophilisation: the frozen samples were subjected to lyophilisation using the device Christ ALPHA1-2 LDPLUS (Osterode am Harz, Germany). The lyophilisation parameters were set to a absolute pressure of 1.6 Pa, a condenser temperature of -57°C, and process duration of 24 hours.
Post-Lyophilisation Processing: after lyophilisation, the dehydrated samples were finely ground into a powder of uniform particle size using a universal laboratory mill, type: WZ-1 (solem, ZBPP, Bydgoszcz, Poland).

Chemical analysis
Proximate chemical composition of cookie samples was conducted according to AOAC (Horowitz, 2019) standard methods: protein content (method No. 950.36), starch content (method No. 996.11), total sugars content (method No. 2020.07), cellulose content (method No. 973.18), lipid content (method No. 935.38) and ash content (method No. 930.22). Each measurement was performed in three replications.

Minerals analysis
The mineral content of potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn) and copper (Cu) of the cookies was determined in accordance to the standard methods of AOAC (Horowitz, 2019). Minerals were determined by atomic absorption spectrophotometry (method No. 984.27) on a Varian Spectra AA 10 (Varian Techtron Pty Ltd., Mulgvare Victoria, Australia). Each measurement was performed in three repetitions.

Methods of Statistical Analysis
Analysis of Variance
Analysis of variance (ANOVA) was applied in order of determinating the variations statistical significance on the set of all cookies' samples tested quality responses. ANOVA analysis was performed by using STATISTICA 12.0 software (2013), (StatSoft Europe, Hamburg, Germany).

Z-Score Analysis
In the Z-Score analysis min-max normalization is used for samples' different response values. They are recalculated and presented in a new dimensionless unit system, with the effort of comparisons and further mathematical calculations of different cookie samples' quality responses (Szarek et al., 2024).
The maximal obtained value of total Z-score values indicates on the optimum value of all segment Z-scores mathematically combined in defined manner, pointing at the optimal combination of all tested quality parameters.
The calculation of individual segment Z-scores is as following:
Cookie samples' technological quality segment Z-score:

$$S_{1i} = \frac{\sum_{k=1}^{12}\left(\frac{x_{ki}-x_{kmin}}{x_{kmax}-x_{kmin}}\right)}{12} \qquad (1)$$

where x_k are: Proteins, Starch, Total sugars, Celullose, Lipids, Ash, Zn, Cu, Mg, Ca, Fe and K.

$$\max [S_i] \rightarrow \text{optimum} \qquad (2)$$

Z-score values were calculated using Microsoft Excel ver. 2016. (Microsoft Corporation, Redmond, WA, USA).

RESULTS AND DISCUSSION

Tables 1 and 2 present the results of the nutritive composition of celery dehydrated by different methods: convective dehydration, lyophilization, and a combined method (osmotic dehydration and lyophilization).

From the results presented in Table 1, it can be seen that celery dried by the combined method (O.D.+L.) has a statistically significantly higher content of proteins, total sugars, and ash, but a lower content of cellulose and lipids compared to celery samples dried by the convective method (C.D.) and lyophilization (L.).

Table 1. Dehydrated celery root chemical composition

Sample:	Proteins (% d.m.)	Starch (% d.m.)	Total sugars (% d.m.)	Cellulose (% d.m.)	Lipids (% d.m.)	Ash (% d.m.)
C.D.*	1.04 ± 0.04^{a}	0.85 ± 0.08^{a}	5.25 ± 0.15^{a}	2.64 ± 0.09^{b}	0.30 ± 0.01^{a}	0.81 ± 0.03^{a}
L.**	1.31 ± 0.05^{b}	1.01 ± 0.05^{b}	5.31 ± 0.09^{a}	2.71 ± 0.05^{b}	0.30 ± 0.01^{a}	0.79 ± 0.02^{a}
O.D.+L.***	4.36 ± 0.19^{c}	1.04 ± 0.03^{b}	24.99 ± 0.99^{b}	1.57 ± 0.04^{a}	0.26 ± 0.00^{a}	4.97 ± 0.49^{b}

* Convectively dehydrated, pulverized, celery root

** Lyophilizated, pulverized, celery root

*** Osmotically dehydrated and lyophilizated, pulverized, celery root

Results are shown as average value ± standard deviation of six replications

$^{a-c}$ Different letters in superscript of the same table column indicate the statistically significant difference between values at a level of significance of $p < 0.05$ (based on post-hoc Tukey HSD test)

The mineral composition of celery dehydrated by different methods is presented in Table 2. Celery dehydrated by the combined method (O.D.+L.) has a statistically significantly higher mineral content in terms of K, Mg, Ca, Fe, Zn, and Cu compared to celery dehydrated by the convective method and lyophilization. During osmotic dehydration stage of the combined method, secondary mass transfer – uptake of the solid from the osmotic solution (sugar beet molasses) in the dehydrating material (celery root) occurs, affecting the change of chemical and mineral content of celery root dry matter (Filipović et al., 2022b). Obtained results in this research also shows the increase of mineral matter content due to dry matter increase from the mineral-rich molasses during the osmotic dehydration stage of the process.

Table 2. Dehydrated celery root mineral content

Sample:	K (mg/100g d.m.)	Mg (mg/100 g d.m.)	Ca (mg/100 g d.m.)	Fe (mg/100 g d.m.)	Zn (mg/100 g d.m.)	Cu (mg/100 g d.m.)
C.D.	308.43 ± 0.94^{a}	23.13 ± 0.11^{a}	73.08 ± 0.21^{a}	0.78 ± 0.03^{a}	0.71 ± 0.02^{a}	0.51 ± 0.02^{a}
L.	309.75 ± 1.05^{a}	23.94 ± 0.24^{a}	73.94 ± 0.34^{a}	0.79 ± 0.02^{a}	0.74 ± 0.04^{ab}	0.52 ± 0.00^{a}
O.D.+L.	1825.74 ± 20.16^{b}	42.74 ± 1.75^{b}	120.49 ± 1.55^{b}	5.39 ± 0.75^{b}	1.35 ± 0.15^{b}	0.84 ± 0.03^{b}

Results are shown as average value ± standard deviation of six replications

$^{a-c}$ Different letters in superscript of the same table column indicate the statistically significant difference between values at a level of significance of $p < 0.05$ (based on post-hoc Tukey HSD test)

Table 3. Z-Score values of dehydrated celery root

Sample:	Z-Score values (%)
C.D.	7.60
L.	15.66
O.D.+L.	91.67

The results of Z-Score analysis, table 3, showed that convectively dehydrated, lyophilized and combined dehydrated celery root obtained: 7.60, 15.66 and 91.67% of total quality, respectively.

CONCLUSIONS

The significant differences between different methods of drying of celery root are confirmed by the application of post-hoc Tukey's HSD test at a 95% confidence limit. Osmotic dehydration stage in the combined dehydration method, influenced mineral mater content increase, due to the molasses content influx into the dehydrating celery root material. The calculation of Z-Score Analysis, based on chemical and mineral parameters, points out the best score of celery root dehydration by the combined method, obtaining 91.67%, while celery lyophilisation and convective dehydration obtained only 15.67% and 7.60% of maximal score values, respectively. Presented data suggests that the combined dehydration method is far superior in retaining celery root's desired chemical and mineral properties compared to lyophilisation and convective dehydration.

ACKNOWLEDGEMENTS

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Универзитет у Новом Саду
НАУЧНИ ИНСТИТУТ ЗА ПРЕХРАМБЕНЕ ТЕХНОЛОГИЈЕ У НОВОМ САДУ
ТЕКУЋИ РАЧУН 340-11007014-16, 265-2010310004498-47, 245-0000000053404-66
МАТИЧНИ БРОЈ 08865485 ШИФРА ДЕЛАТНОСТИ 7219 ПИБ 104743019

Научни институт за прехрамбене технологије у Новом Саду
Примљено 11. 09. 2024.
17/90

УГОВОР
о продаји техничког решења

Закључен дана 12.09.2024. године између

1. **Научни институт за прехрамбене технологије у Новом Саду**, са седиштем у Новом Саду, ул. Булевар цара Лазара бр. 1, МБ 08865485, ПИБ 104743019, кога заступа др Љубиша Шарић, в.д. директор Института (у даљем тексту: институт), контакт особа: др Јелена Филиповић (први аутор)

и

2. **КОРНИ д.о.о** са седиштем у Бару**,** Црна Гора, Београдска 39, РБ 50053700, ПИБ 02358913
кога заступа директор Стеван Главичић (у даљем тексту: купац)

Члан 1.

Предмет овог уговора је продаја техничког решења за производ „Слани кекс са дехидрираним целером" аутора: Јелена Филиповић, Миленко Кошутић, Милица Нићетин, Владимир Филиповић, Ивица Ћаловић, Горан Триван и Драгица Станковић као и техничке и друге подршке током реализације техничког решења у производњи.

Члан 2.

Институт се обавезује да купцу прода техничко решење за производ „Слани кекс са дехидрираним целером" и да купцу пружи консултантске услуге.

Члан 3.

Институт се обавезује да све информације до којих дође у свом истраживачком раду, а везане су за предмет овог уговора, третира као пословну тајну. Наведене информације могу бити доступно искључиво Купцу.

Институт нема права да предмет овог уговора прода неком трећем лицу.

Члан 4.

Купац се обавезује да Институту за предмет овог уговора плати накнаду у износу од 100 евра (сто евра) увећан за вредност ПДВ-а у року од 8 дана од дана пријема рачуна, на текући рачун број: 340-11007014-16 који се води код Ерсте банке.

Члан 5.

Купаца се обавезује да се придржава обавезних параметара производње проистеклих из техничког решења, и да производ пласира на тржиште уз поштовање важећих прописа.

Члан 6.

Уколико једна уговорна страна претрпи штету услед незаконитог понашања друге уговорне стране, уговорна страна која је нанела штету дужна је у целости накнадити је уговорној страни која је претрпела штету.

Члан 7.

Уговорне стране се обавезују да све евентуалне спорове проистекле из овог уговора реше мирним путем. Уколико то не буде било могуће, уговара се надлежност Привредног суда у Новом Саду.

Члан 8.

Уговор ступа на снагу даном потписивања од стране овлашћених лица уговорених страна.

Члан 9.

Овај уговор је сачењен у 4 (четири) истоветна примерка, од којих 2 (два) примерка задржава Купац, а 2 (два) Институт.

За Купца

Стеван Главичић
директор

За Институт

др Љубиша Шарић
в.д. директора Института

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MB Banke/MB Komitenta: Bank ID/Client ID: 17335600/8865485

Broj izvoda: Number: 71

Valuta: Currency: 978/EUR

Naziv računa: Account name: Devizni računi preduzeća i drugih pravnih lica

NAUCNI INSTITUT ZA PREHRAMBENE TEHNOLOGIJE U NOVOM SADU NOVI SAD
BULEVAR CARA LAZARA 1
21102 NOVI SAD
Devizno knjigovodstvo
Izvod je važeći bez pečata i potpisa

RB: No:	Datum izvršenja/ *Datum prijema	Dodatne inf. / NBS Statistika: Additional information /NBS Statistics:	Duguje: Debit:	Potražuje: Credit:
Prethodno stanje: Opening balance:				**258,683.21**
1	08.10.2024 *09.10.2024	KORNI D.O.O. BAR BJELISI 260 ME/85000 BAR/ME /INV/Izrada projekta//INV/Izrada projekta NBS: Slog 60 Osnov 303 100.00 13/2024 - Istraživanje i razvoj-projekti,arheološka istraž,laborat. Us Iznos upucen od strane ino partnera 100.00 Posebna oznaka 1 Knjiženje priliva po loro doznaci za pravna lica Ref:1101133405981/Br.naloga:1018303666000002		100.00 11,702.98
2	09.10.2024 *09.10.2024	MULTI LAB D.O.O. TUZLA, PLANE BB, TUZLA, BA/BA 499 RACUN 24 303 000015/499 RACUN 24 303 000015 NBS: Slog 60 8035 FOODTECH Osnov 303 320.00 24-303-000015/2024 - Istraživanje i razvoj-projekti,arheološka istraž, Iznos upucen od strane ino partnera 320.00 Posebna oznaka 1 Knjiženje priliva po loro doznaci za pravna lica Ref:1101133418129/Br.naloga:35405240147000002		320.00 37,449.54
3	09.10.2024 *09.10.2024	MAGYAR AGRAR- ES ELETTUD. EGYETEM HU 2100 GODOLLO PATER KAROLY UTCA 1/HU /ROC/U44N192507241008///URI/PROFORM A-INVOICE 24-011-000084RECEIPT NUMB ER:24-0265RZBSRSBG//ROC/U44N192507241008///URI/PROFO RM A-INVOICE 24-011-000084RECEIPT NUMB ER:24-0265RZBSRSBG NBS: Slog 60 Osnov 303 170.00 24-011-000084/2024 - Istraživanje i razvoj-projekti,arheološka istraž, Iznos upucen od strane ino partnera 170.00 Posebna oznaka 1 Knjiženje priliva po loro doznaci za pravna lica Ref:1101133417289/Br.naloga:1022893666000002	AV 24-370-177	170.00 19,895.07

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Broj izvoda: / Number:	71
Valuta: / Currency:	978/EUR
Naziv računa: / Account name:	Devizni računi preduzeća i drugih pravnih lica

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BULEVAR CARA LAZARA 1
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Devizno knjigovodstvo
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RB: / No:	Datum izvršenja/ *Datum prijema	Dodatne inf. / NBS Statistika: / Additional information /NBS Statistics:	Duguje: / Debit:	Potražuje: / Credit:
Prethodno stanje: / Opening balance:				**258,683.21**
1	08.10.2024 *09.10.2024	KORNI D.O.O. BAR BJELISI 260 ME/85000 BAR/ME /INV/Izrada projekta//INV/Izrada projekta NBS: Slog 60 Osnov 303 100.00 13/2024 - Istraživanje i razvoj-projekti,arheološka istraž,laborat. Us Iznos upucen od strane ino partnera 100.00 Posebna oznaka 1 Knjiženje priliva po loro doznaci za pravna lica Ref:1101133405981/Br.naloga:1018303666000002		100.00 *11,702.98*
2	09.10.2024 *09.10.2024	MULTI LAB D.O.O. TUZLA, PLANE BB, TUZLA, BA/BA 499 RACUN 24 303 000015/499 RACUN 24 303 000015 NBS: Slog 60 8035 FOODTECH Osnov 303 320.00 24-303-000015/2024 - Istraživanje i razvoj-projekti,arheološka istraž, Iznos upucen od strane ino partnera 320.00 Posebna oznaka 1 Knjiženje priliva po loro doznaci za pravna lica Ref:1101133418129/Br.naloga:3540524014700002		320.00 *37,449.54*
3	09.10.2024 *09.10.2024	MAGYAR AGRAR- ES ELETTUD. EGYETEM HU 2100 GODOLLO PATER KAROLY UTCA 1/HU /ROC/U44N192507241008///URI/PROFORM A-INVOICE 24-011-000084RECEIPT NUMB ER:24-0265RZBSRSBG//ROC/U44N192507241008///URI/PROFO RM A-INVOICE 24-011-000084RECEIPT NUMB ER:24-0265RZBSRSBG NBS: Slog 60 Osnov 303 170.00 24-011-000084/2024 - Istraživanje i razvoj-projekti,arheološka istraž, Iznos upucen od strane ino partnera 170.00 Posebna oznaka 1 Knjiženje priliva po loro doznaci za pravna lica Ref:1101133417289/Br.naloga:1022893666000002	AV 24-370-177	170.00 *19,895.07*

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FINS

NAUČNI INSTITUT ZA PREHRAMBENE TEHNOLOGIJE U NOVOM SADU
Bulevar cara Lazara 1
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Matični broj: 08865485
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Dostavljena na	9.10.2024.	**Prijemnica br:**	24-0288/9.10.2024.	**Dostava**
Datum valute	9.10.2024.	**Otpremnica:**	UGOVOR BR.17/90/12.9.2024.	**Odgovorna osoba**
Mesto, dana	9.10.2024.			

Račun 24-303-000016

Ident	Naziv	Količina	JM	Cena	R. %	PDV %	Vrednost bez PDV
USLUGA INO	TEHNIČKO REŠENJE ZA PROIZVOD SLANI KEKS SA DEHIDRIRANIM CELEROM	1,00	KOM	100,00	0,00	0,00	100,00

ID za PDV 02358913

Slovima sto EUR 00/100

Ukupno		**100,00**
PDV		**0,00**
Za plaćanje	**EUR**	**100,00**

PORESKE STOPE	Osnova	PDV	Vrednost
Promet dobara sa pravom odbitka prethodnog poreza	100,00	0,00	100,00

PDV NIJE OBRAČUNAT U SKLADU SA ČLANOM 12 STAV 4 ZAKONA O PDV-U

Pri plaćanju s platnim nalogom upotrebite model 12 i poziv .

Univerzitet u Novom Sadu
NAUČNI INSTITUT ZA PREHRAMBENE TEHNOLOGIJE U NOVOM SADU

TEKUĆI RAČUN 340-11007014-16, 265-2010310004498-47, 245-0000000053404-66
MATIČNI BROJ 08865485 **ŠIFRA DELATNOSTI** 7219 **PIB** 104743019

Naučni institut za prehrambene tehnologije u Novom Sadu
Naučnom veću Instituta - u kući

PREDMET: Molba za davanje saglasnosti za predloženu kategorizaciju tehničkog rešenja

Tehničko rešenje "**Slani keks sa dehidriranim celerom**" je nov proizvod koji se proizvodi u pogonu d.o.o Korni u Baru na teritoriji Republike Crne Gore.

Predlaže se kategorija Novo tehničko rešenje primenjeno na međunarodnom nivou **M81** jer sadrži sve neophodne elemente: dokaz o korišćenju novog proizvoda na međunarodnom nivou, ugovor o prodaji tehničkog rešenja.

Autori tehničkog rešenja su: dr Jelena Filipović, dr Milenko Košutić, dr Milica Nićetin, dr Vladimir Filipović, dr Ivica Đalović, dr Goran Trivan, dr Dragica Stanković.

Novi Sad, 14.10.2024.

Podnosilac zahteva
Dr Jelena Filipović, naučni savetnik

Jelena Filipović

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Univerzitet u Novom Sadu

NAUČNI INSTITUT ZA PREHRAMBENE TEHNOLOGIJE U NOVOM SADU

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UNIVERZITET U NOVOM SADU
Naučni institut za prehrambene tehnologije u Novom Sadu
Broj: 2/1-3/6-1
Dana: 28. 10. 2024.

Izvod iz Zapisnika sa konstitutivne sednice Naučnog veća Naučnog instituta za prehrambene tehnologije u Novom Sadu (u daljem tekstu Institut), koja je održana 28. oktobra 2024. u prostorijama Edu centra na III spratu u 9 časova.

nepotrebno izostavljeno

Ad VI

Naučno veće Naučnog instituta za prehrambene tehnologije u Novom Sadu na konstitutivnoj sednici održanoj dana 28. 10. 2024. godine donosi

ODLUKU

NV Instituta daje saglasnost za predloženu kategorizaciju M81 tehničkog rešenja pod nazivom: "Slani keks sa dehidriranim celerom".
Autori tehničkog rešenja: dr Jelena Filipović, dr Milenko Košutić, dr Milica Nićetin, dr Vladimir Filipović, dr Ivica Đalović, dr Goran Trivan, dr Dragica Stanković.

Predsednica Naučnog veća

Dr Tamara Dapčević Hadnađev