ENZİME DİRENÇLİ NİŞASTA İÇERİĞİNİN ARTIRILMASINA YÖNELİK YENİ UYGULAMALAR

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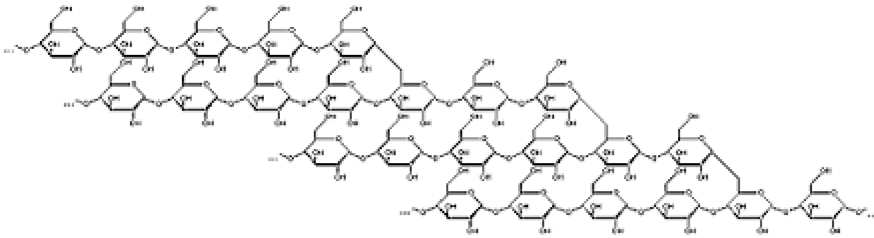
Nişasta



α-D-glukoz birimlerinden oluşan bir polisakkarittir

1- Hızlı Sindirilebilen Nişasta

Amorf ve dispers haldeki nişastadır

2- Yavaş Sindirilebilen Nişasta

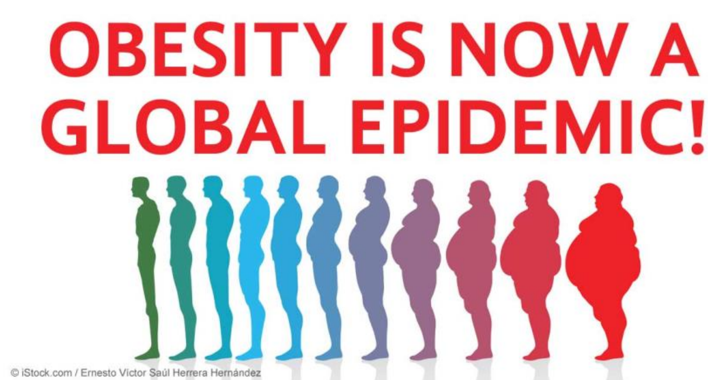
Tamamen ancak çok yavaş sindirilebilen nişastadır

3- Dirençli Nişasta

Sağlıklı bireylerin ince bağırsağında sindirilemeyen nişasta

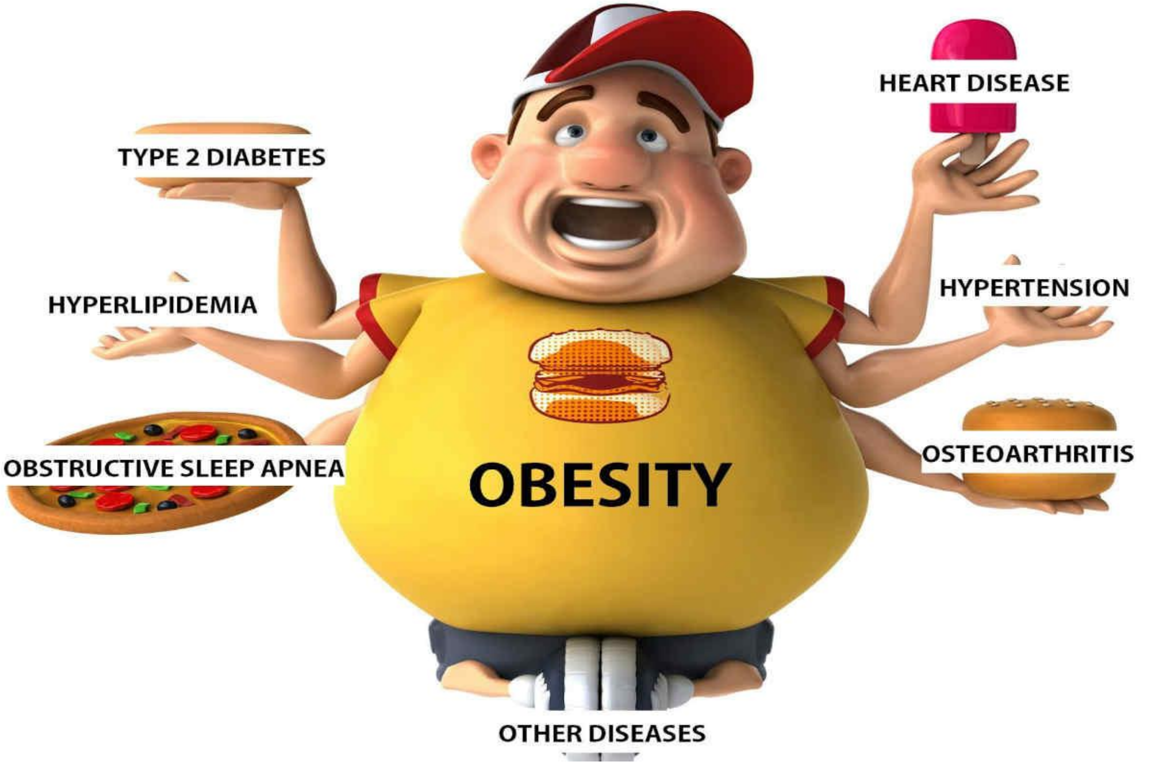
HSN vs. EDN

- Çeşitli gıda işleme yöntemlerinin Hızlı Sindirilebilir Nişasta (HSN) fraksiyonunu arttırdığı (Englyst ve ark., 1992)
- HSN'sı yüksek gıdalar genelde daha yüksek glisemik indekse sahiptir
- Yüksek glisemik indeksi olan gıdalar düşük tokluk ile ilişkilidir ve aşırı gıda alımını teşvik ettiği gösterilmiştir, bu da obezite riskine katkıda bulunabilir (Ludwig ve diğerleri, 1999).



- Glisemik indeksi yüksek gıdalar, tip II diyabet riskini artırmakta (Salmeron ve ark., 1997) ve kardiyovasküler hastalık riskini de beraberinde getirmektedir (Liu ve ark., 2000).

- Dolayısıyla glisemik indeksi yüksek gıdalar genellikle insan sağlığı üzerinde olumsuz etkiler yaratmaktadır.

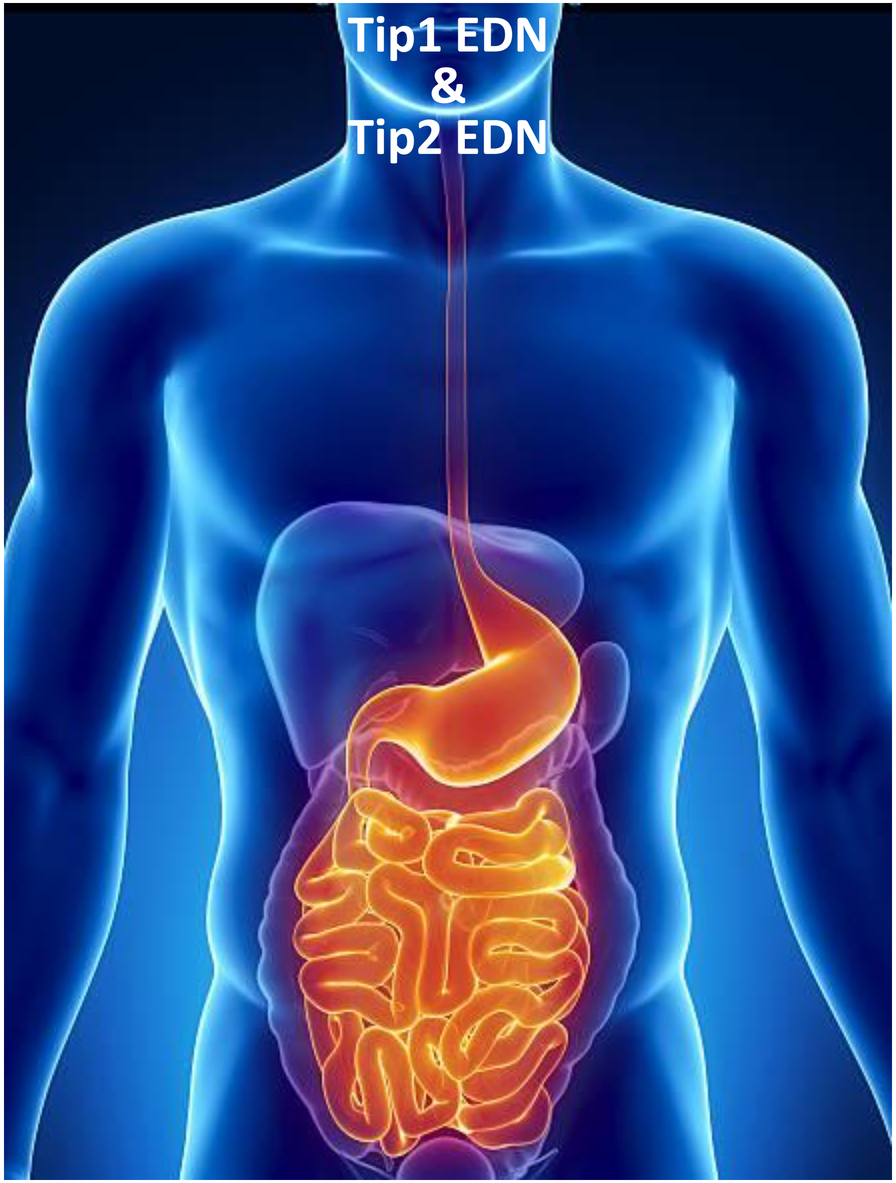


- Yavaş Sindirilebilir Nişasta (YSN) ve Enzime Dirençli Nişasta (EDN) içeriği yüksek gıdalar daha düşük glisemik indekse sahiptir.
- EDN kalın bağırsaklara ulaşabilmekte ve bağırsak mikroflorası tarafından fermente edilmektedir. Bu nedenle ince bağırsakta sindirilemeyen besinsel lifin bir fraksiyonu olarak tanımlanmaktadır.
- EDN tüketildikten sonra tokluk hissi yaratmakta, bu da vücut ağırlığını düzenlemek için yardımcı olur (Willis ve ark., 2009).

- EDN aynı zamanda kolonik mikroflora ile fermente edilerek ağırlıklı olarak asetik, propiyonik ve bütirik asit gibi kısa zincirli yağ asitleri üretilmektedir (Scheppach 1994).
- Çalışmalar, EDN’nin vücuttaki kolon kanseri ve diğer kanser oluşumlarını engellemesine yardımcı olabileceğini ve bunun da bütiratın artan üretimine ve kolonositlere olan pozitif etkilerine dikkat çekmektedir (Hamer ve ark., 2008).

Enzime Dirençli Nişasta

EDN Tipi	Tanımı	Bulunduğu Kaynak
Tip1 EDN	Sindirilemeyen matriks içinde tutuklu halde bulunan nişasta	Hücre duvarı zarar görmemiş kısmen öğütülmüş tahıl ve baklagil taneleri
Tip2 EDN	Granül formdaki jelatinize olmamış kısmen dehidre olmuş nişasta	Ham patates, yeşil muz, yüksek amilozlu mısır nişastası
Tip3 EDN	Fiziksel olarak modifiye edilmiş **retrograde nişasta**	Pişirilip soğutulmuş patates, kahvaltılık tahıl ürünleri, ekmek
Tip4 EDN	İki nişasta molekülünün kovalent bağlanmasıyla oluşan nişasta	Çapraz bağlı nişastalar, fosfat ve sitrat nişastaları
Tip5 EDN	Amiloz-lipid kompleksleri	Amiloz zincirleri lipid komponentleri ile kompleks oluşturan nişastalar



Tip1 ve Tip2 EDN gıdaların uygun bir şekilde ön işlenmesi ile yavaş da olsa sindirilebilirken,

Tip3 ve Tip4 EDN sindirime karşı direnç göstermektedir (Vasanthan ve Bhatty, 1998)

Termal stabilitesi nedeniyle EDN tipleri içinde en çok ilgi çeken

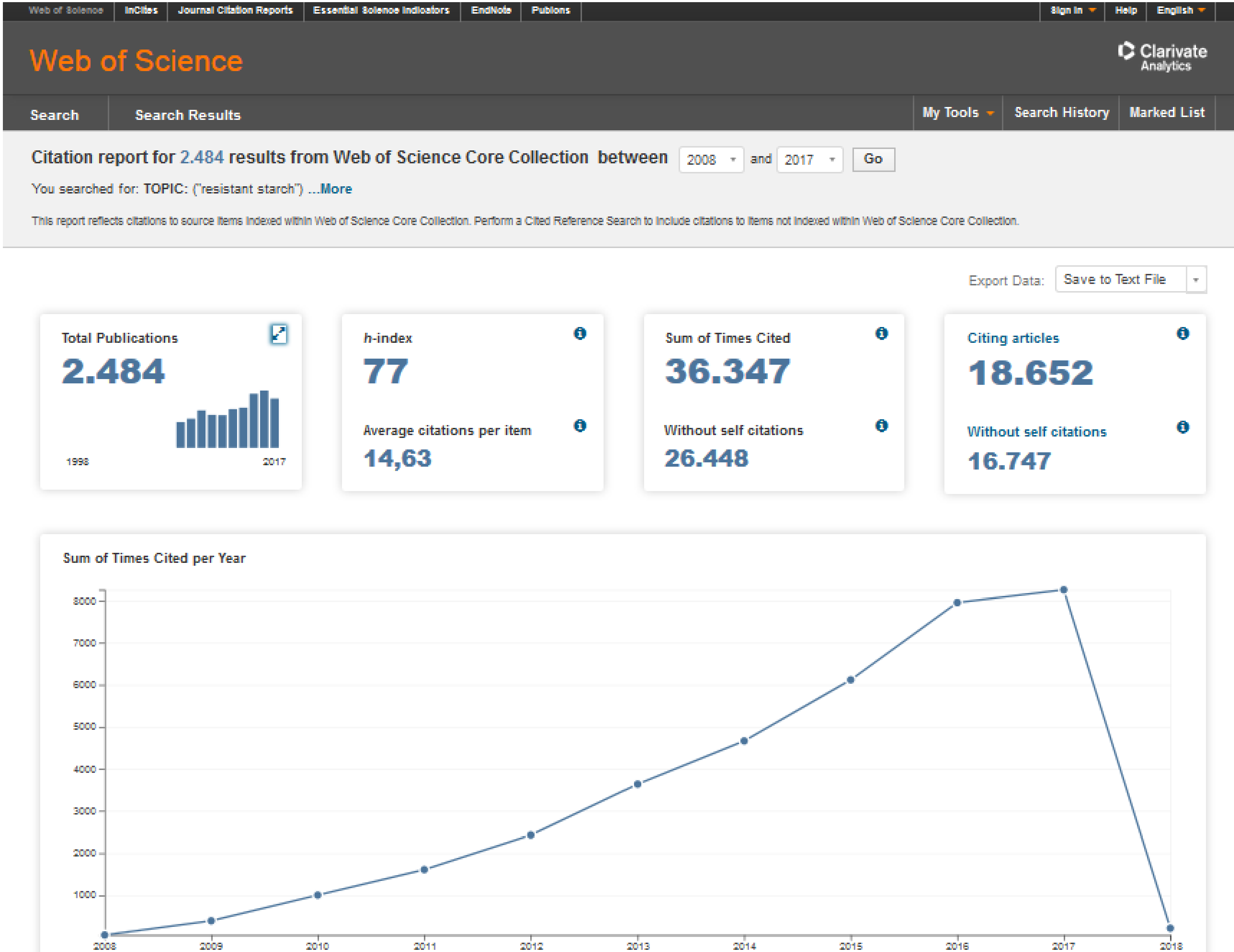
Tip3 EDN' dir.

Bu özelliği;

- normal pişirme işlemlerinde stabil olmasını ve
- besinsel özelliğini korumasını,
- birçok gıdada ingrediyen olarak kullanılabilmesini sağlamaktadır

Bu nedenle gıdanın Tip3 EDN içeriğinin farklı proseslerle arttırılması ile ilgili çalışmalar giderek önem kazanmaktadır.

Son on yılın verilerine bakalım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EDN İçeriğinin Arttırılmasına Yönelik Uygulamalar

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Impact of annealing and heat-moisture treatment on rapidly digestible, slowly digestible and resistant starch levels in native and gelatinized corn, pea and lentil starches ☆

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ABSTRACT

Impact of annealing (ANN) and heat-moisture treatment (HMT) on rapidly digestible starch (RDS), slowly digestible starch (SDS), resistant starch (RS), and expected glycemic index (eGI) of corn, pea, and lentil starches in their native and gelatinized states were determined. ANN was done for 24 h at 70% moisture at temperatures 10 and 15 °C below the onset (T_o) temperature of gelatinization, while HMT was done at 30% moisture at 100 and 120 °C for 2 h. The swelling factor (SF), amylose leaching (AML) and gelatinization parameters of the above starches before and after ANN and HMT were determined. SF and AML decreased on ANN and HMT (HMT > ANN). The gelatinization temperatures increased on ANN and HMT (HMT > ANN). However, the gelatinization temperature range decreased on ANN but increased on HMT. Birefringence remained unchanged on ANN but decreased on HMT. The Fourier transform infrared (FT-IR) absorbance ratio of 1047 cm^{-1}/1022 cm^{-1} increased on ANN but decreased on HMT. ANN and HMT increased RDS, RS and eGI levels and decreased SDS levels in granular starches. HMT had a greater impact than ANN on RDS, RS, and SDS levels. In gelatinized starches, ANN and HMT decreased RDS and eGI, but increased SDS and RS levels. These changes were more pronounced on HMT. This study showed that amylopectin structure and interactions formed during ANN and HMT had a significant impact on RDS, SDS, RS and eGI levels of starches.

Table 3
RDS, SDS and RS levels in native and gelatinized starches subjected to annealing and heat-moisture treatment[a]

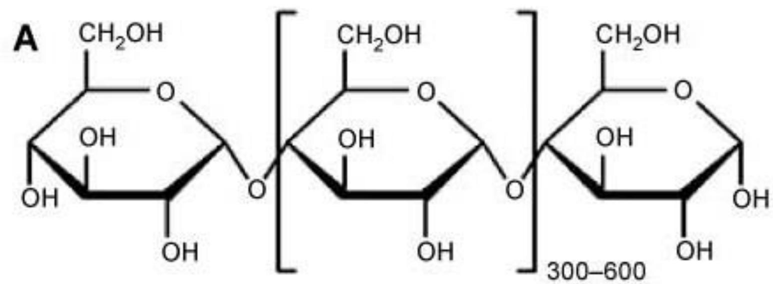
Sample	Native starch			Gelatinized starch		
	RDS (%)[b]	SDS (%)[b]	RS (%)[b]	RDS (%)[b]	SDS (%)[b]	RS (%)[b]
NC[c]	29.7 ± 1.9	65.7 ± 1.3	4.6 ± 1.8	95.3 ± 2.0	0.1 ± 0.2	4.6 ± 1.8
NP[c]	27.0 ± 2.5	62.9 ± 0.7	10.0 ± 2.4	94.2 ± 1.0	0.6 ± 1.0	5.2 ± 0.8
NL[c]	20.8 ± 1.8	70.1 ± 2.2	9.1 ± 1.2	93.9 ± 0.6	0.8 ± 0.8	5.3 ± 0.6
CA15[d]	43.4 ± 0.6	48.6 ± 2.2	8.0 ± 1.7	94.7 ± 1.1	0.1 ± 0.2	5.2 ± 1.2
PA15[d]	29.3 ± 1.0	59.8 ± 1.3	10.9 ± 1.3	87.9 ± 1.9	1.9 ± 1.4	10.2 ± 0.6
LA15[d]	30.4 ± 1.6	60.4 ± 1.8	9.2 ± 2.1	90.1 ± 2.5	1.9 ± 0.4	8.0 ± 2.2
CA10[e]	59.9 ± 1.7	31.4 ± 0.3	8.7 ± 1.5	90.2 ± 2.0	1.6 ± 1.1	8.2 ± 1.8
PA10[e]	53.4 ± 1.1	34.4 ± 0.5	11.2 ± 1.3	87.7 ± 2.6	1.8 ± 1.9	10.5 ± 0.8
LA10[e]	57.8 ± 1.7	30.8 ± 1.5	11.4 ± 0.5	89.8 ± 1.5	1.5 ± 1.2	8.7 ± 0.9
CH100[f]	65.2 ± 1.3	24.2 ± 1.4	10.5 ± 1.0	87.9 ± 1.4	2.4 ± 1.3	9.7 ± 0.8
PH100[f]	60.8 ± 0.8	25.9 ± 2.0	13.3 ± 1.5	84.9 ± 1.1	3.5 ± 1.6	11.6 ± 1.7
LH100[f]	56.4 ± 2.0	30.4 ± 2.2	13.2 ± 0.5	81.6 ± 2.4	5.2 ± 2.7	13.2 ± 1.4
CH120[g]	70.4 ± 0.4	17.3 ± 2.2	12.3 ± 1.9	85.1 ± 0.6	2.6 ± 1.3	12.3 ± 0.8
PH120[g]	71.7 ± 0.7	13.8 ± 1.0	14.5 ± 1.2	80.2 ± 1.4	3.4 ± 1.6	16.4 ± 0.4
LH120[g]	61.7 ± 1.6	23.6 ± 3.0	14.7 ± 2.0	78.8 ± 2.5	5.5 ± 2.3	15.7 ± 0.6

[a] Mean (±standard deviation) of duplicate analysis.
[b] RDS, rapidly digestible starch; SDS, slowly digestible starch; RS, resistant starch.
[c] NC, NP, NL – unmodified corn, pea and lentil starches.
[d] Annealed (T_o – 15 °C, 70% moisture, 24 h) corn (CA15), pea (PA15) and lentil (LA15) starches.
[e] Annealed (T_o – 10 °C, 70% moisture, 24 h) corn (PA10), pea (PA10) and lentil (LA10) starches.
[f] Heat-moisture treated (100 °C, 30% moisture, 2 h) corn (CH100), pea (PH100) and lentil (LH100) starches.
[g] Heat-moisture treated (120 °C, 30% moisture, 2 h) corn (CH120), pea (PH120) and lentil (LH120) starches.

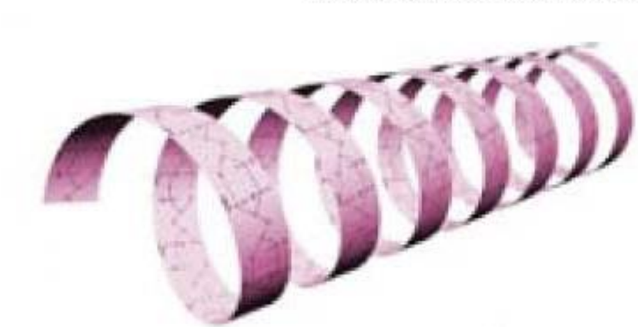
Mısır, bezelye ve mercimek nişastaları üzerine %30 nem içeriğinde 120°C'de 2 saat uygulanan Sıcaklık-Nem İşlemi (HMT) neticesinde (jelatinize olan örneklerde) EDN miktarlarında sırasıyla; %7.7, %11.2 ve %10.4 oranında artış tespit edilmiştir.

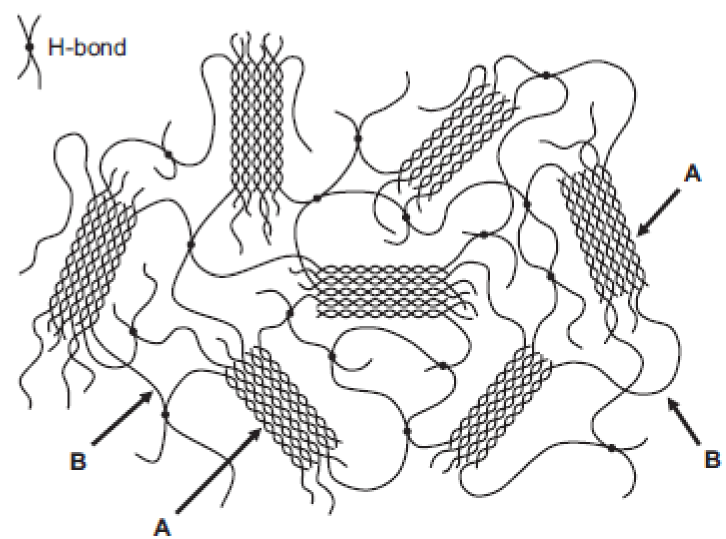
Otoklav ve Retrogradasyon Döngüleri

- Otoklav retrogradasyon uygulamalarında, nişasta basınç altında 100°C’nin üzerindeki sıcaklıklarda jelatinize olur.
- Bu süre zarfında, nişasta granülleri tamamen parçalanır ve soğumaya başlandığında amiloz zincirleri, hidrojen bağları ile stabil çift sarmal oluşturmak üzere birleşebilir.



Amylose with a linear helical structure





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- Bunlar sırayla Tip3 EDN kristalitlerini oluştururlar ve sıkı yapılarından dolayı nişastayı hidrolize eden enzimlere karşı direnç gösterirler.

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Improving effect of lyophilization on functional properties of resistant starch preparations formed by acid hydrolysis and heat treatment

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Abstract

In this study, effects of lyophilization on the functional properties of acid modified and autoclaved corn starch preparations were investigated. RS contents and pasting properties of these starch preparations were also determined. Significant increases in solubility were observed as the hydrolysis level of the lyophilized samples increased. All of the acid-modified gelatinized–autoclaved–lyophilized samples had higher water binding values than those of native starch and heat treated oven-dried native starch. Acid-modified gelatinized–autoclaved–lyophilized samples (with storage at 95°C: GASL or without storage: GAL, before lyophilization) improved

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Production of resistant starch from acid-modified amylotype starches with enhanced functional properties

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ABSTRACT

Amylotype corn starches, Hylon V and Hylon VII, were acid-hydrolyzed followed by autoclaving–storing cycles and drying in an oven or freeze-dryer. Molecular weights of the samples decreased with increasing hydrolysis time. Resistant starch (RS) contents of acid-hydrolyzed samples did not differ from those of native starches. RS contents of oven-dried samples were higher than those of freeze-dried samples. Onset (T_O) and peak (T_P) transition temperatures of hydrolysates were lower than those of respective native starches. Autoclaving–storing increased in T_O and T_P and decreased in ΔH values as compared to acid-hydrolyzed starches. Water binding and solubility values of hydrolysates were higher than those of respective native starches. Autoclaved-stored samples had higher water binding and solubility values than those of respective acid-hydrolyzed samples. Acid-hydrolyzed and autoclaved-stored samples increased the emulsion capacity and stability values of albumin. The RVA viscosity values of the autoclaved-stored samples were higher than those of the hydrolysates.

Table 2
The effects of autoclaving–storing cycles and drying conditions on RS_3 contents and thermal properti

Treatment	Oven-dried			
	RS_3 (%)	T_O (°C)	T_P (°C)	ΔH (J/g)
H5-N	–	145.5 ab	158.0 a	11.4 a
H5-N(A133 S4)	26.7 a	149.6 a	154.3 b	8.3 b
H5-N(A133 S95)	26.8 a	150.0 a	154.0 b	5.8 c
H5-1(A133 S4)	26.2 a	148.3 a	153.8 b	6.8 c
H5-1(A133 S95)	26.0 a	150.0 a	152.8 bc	6.1 c
H5-2(A133 S4)	23.6 b	140.1 b	151.4 bc	8.9 b
H5-2(A133 S95)	23.4 b	146.2 a	151.6 bc	8.6 b
H5-3(A133 S4)	27.4 a	144.6 ab	150.0 c	8.7 b
H5-3(A133 S95)	27.7 a	145.4 ab	150.3 c	8.8 b
H7-N	–	146.8 a	157.7 a	14.8 a
H7-N(A133 S4)	37.4 a	147.5 a	152.3 bc	6.8 c
H7-N(A133 S95)	37.3 a	148.9 a	153.8 b	6.4 c
H7-1(A133 S4)	39.5 a	147.9 a	152.4 bc	5.8 d
H7-1(A133 S95)	36.6 b	148.3 a	152.6 b	5.6 d
H7-2(A133 S4)	38.0 a	144.6 a	150.8 c	5.6 d
H7-2(A133 S95)	36.4 b	147.5 a	151.0 c	5.8 d
H7-3(A133 S4)	38.7 a	146.2 a	150.0 c	7.5 b
H7-3(A133 S95)	36.6 b	146.1 a	150.5 c	7.5 b

[A] For each sample, means with different letters within each column are significantly different (*p*
[B] RS_3: type 3 resistant starch; T_O: onset temperature; T_P: peak temperature; ΔH: enthalpy; H5: Hy
A133: autoclaved at 133 °C for 30 min; S4 or S95: stored at 4 or 95 °C; see Section 2 for details on

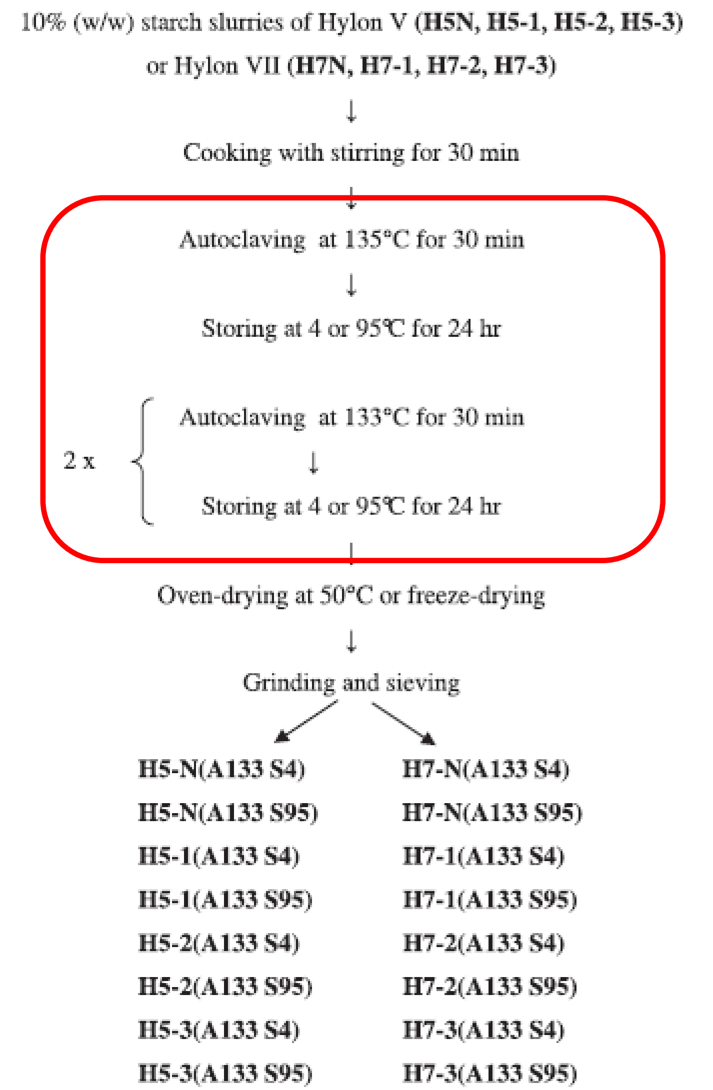


Fig. 1. Flow chart for resistant starch formation. H5: Hylon V; H7: Hylon VII; N: native; 1, 2, 3: acid hydrolysis time (h); A133: autoclaved at 133 °C; S4 or S95: stored at 4 or 95 °C.

Characterization of Resistant Starch Samples Prepared from Two High-Amylose Maize Starches Through Debranching and Heat Treatments

Serpil Ozturk,[1] Hamit Koksel,[2,3] and Perry K.W. Ng[4]

ABSTRACT

Cereal Chem. 86(5):503–510

The aim of the present study was to investigate effects of debranching, autoclaving-storing cycles, and drying processes (oven-drying or freeze-drying) on RS contents, thermal, pasting, and functional properties of high-amylose maize starches (Hylon V and Hylon VII). The resistant starch (RS) contents increased (≤57.8%) with increasing autoclaving-storing cycles. RS contents of oven-dried samples were higher than those of freeze-dried samples due to ongoing retrogradation of starch during oven drying at 50°C. Debranching caused a significant decrease in peak transition temperature and enthalpy values as compared with native starches. Solubility and water binding values of RS preparations were

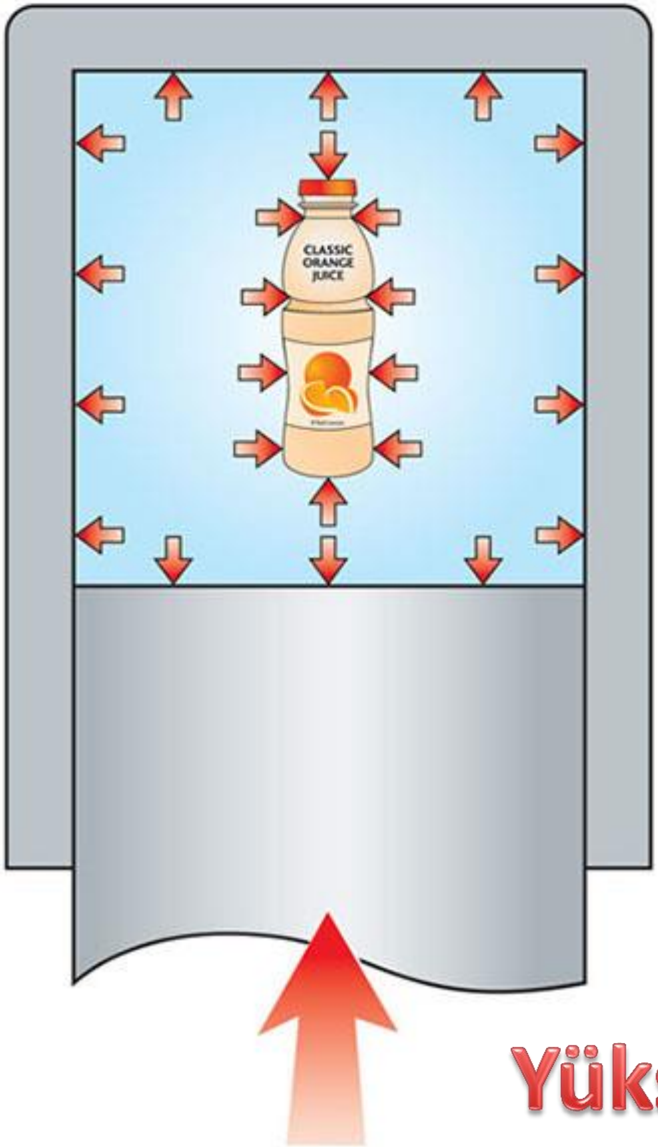
TABLE I
Effects of Autoclaving-Storing Cycles and Drying Conditions on RS Contents of Starch Samples[a]

	RS_3 (%)	
Treatment[b]	Oven-Dried	Freeze-Dried
H5A	27.3c	17.7c
H5A-D	41.5b	24.4ab
H5A-D-3(A133 S4)	44.6b	19.8b
H5A-D-3(A133 S95)	44.7b	27.6ab
H5A-D-6(A133 S4)	42.2b	27.1ab
H5A-D-6(A133 S95)	48.3a	21.4ab
H5A-D-9(A133 S4)	42.2b	27.5a
H5A-D-9(A133 S95)	47.7a	30.5a
H7A	29.1f	23.5e
H7A-D	40.9e	33.1d
H7A-D-3(A133 S4)	42.6de	38.8b
H7A-D-3(A133 S95)	43.5cd	36.5c
H7A-D-6(A133 S4)	45.2c	43.4a
H7A-D-6(A133 S95)	49.5b	42.1a
H7A-D-9(A133 S4)	51.7b	42.6a
H7A-D-9(A133 S95)	57.8a	41.9a

[a] For each sample, means with different letters within each column are significantly different ($P < 0.05$).

[b] H5, Hylon V; H7, Hylon VII; A, autoclaved at 135°C for 30 min; D, debranched for 48 hr; A133, autoclaved at 133°C; S4 or S95, stored at 4°C or 95°C for 3, 6, and 9 autoclaving-storing cycles at different drying conditions.

Enzime Dirençli Nişasta içerikleri otoklavlama-depolama döngüleri artıkça artmıştır.



Yüksek Hidrostatik Basınç

- Yüksek basınçlı işleme, nişastanın su içinde hazırlanan süspansiyonunun vakum altında ambalajlanması ve hermetik olarak kapatılmış içeriğin tipik olarak 10 ila 1200 MPa aralığında büyük bir basınç uygulanmasıyla gerçekleştirilir (Stute ve ark., 1996).
- Nişastaya uygulanan basınç neticesinde daha düşük sıcaklıklarda dahi kısmi jelatinizasyon ve basıncın serbest bırakılmasıyla spontan olarak retrogradasyon meydana gelmektedir.
- Buda EDN oluşumunu teşvik etmektedir (Linsberger-Martin ve ark., 2012).

Starch/Stärke 2012, *64*, 157–165 DOI 10.1002/star.201100065

RESEARCH ARTICLE

Effects of high hydrostatic pressure on the RS content of amaranth, quinoa and wheat starch

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RS exerts a range of beneficial effects on human health. Therefore, ways to increase the RS content in processed food products are looked for. The effects of high hydrostatic pressure treatments on the RS content of wheat, quinoa and amaranth starch were analysed in this study. A 2^3 factorial screening design of experiments was used. Experimental factors were pressure (100–600 MPa), temperature (40–60°C) and time (10–30 min). RS in wheat starch increased with increasing pressure by a factor of up to 10 to a value of 4%. In detail, RS content increased significantly at pressures higher than 100 MPa in wheat starch, whereas in quinoa starch significant changes occurred at pressures above 350 MPa (up to 3.3% RS compared to 0.2% in native quinoa starch). Contrary, in amaranth starch the RS content of all pressure treated samples (about 0.5%) was lower than that of the native starch (1.3%). Wheat starch granules swelled to a maximum of 3.67 times their original size and quinoa starch up to 3.36 times. The extent of swelling (2.90) was lowest in amaranth starch.

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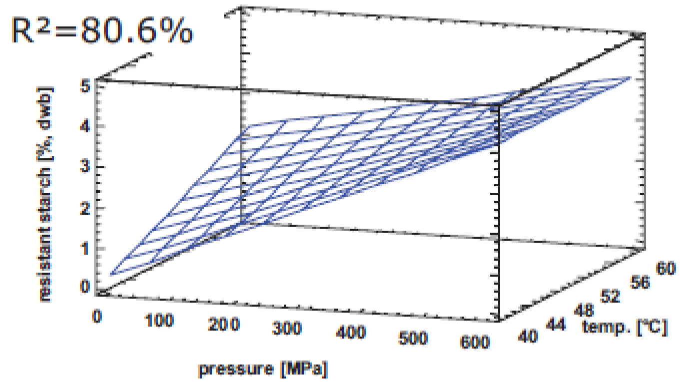
Amaranth / AM / High hydrostatic pressure / RS / Quinoa



Buğday nişastası

100 MPa, 40°C/30 dak YHB %0.28

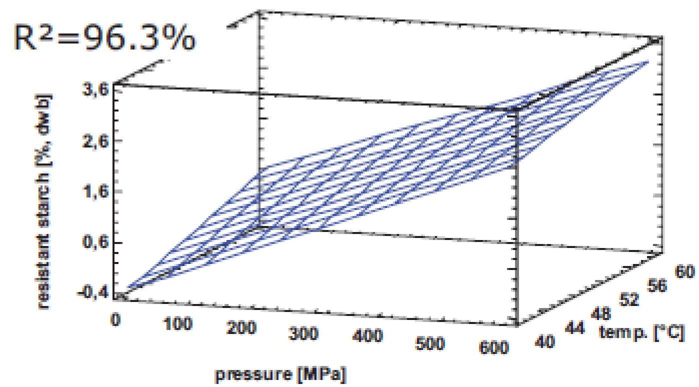
600 MPa, 40°C/30 dak YHB %4.00

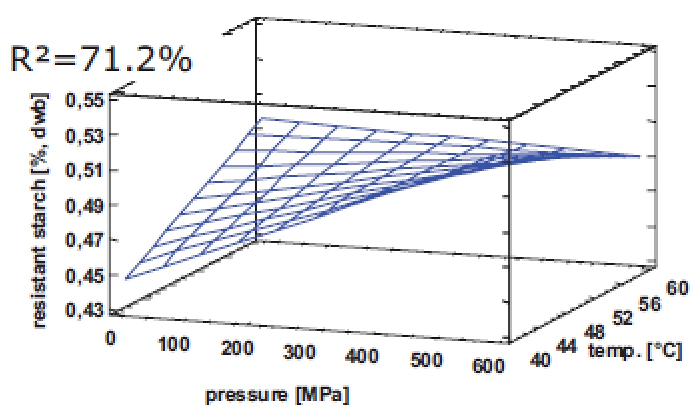
Kinoa nişastası

100 MPa, 40°C/30 dak YHB %0.04

100 MPa, 60°C/30 dak YHB %1.77

600 MPa, 60°C/30 dak YHB %3.32

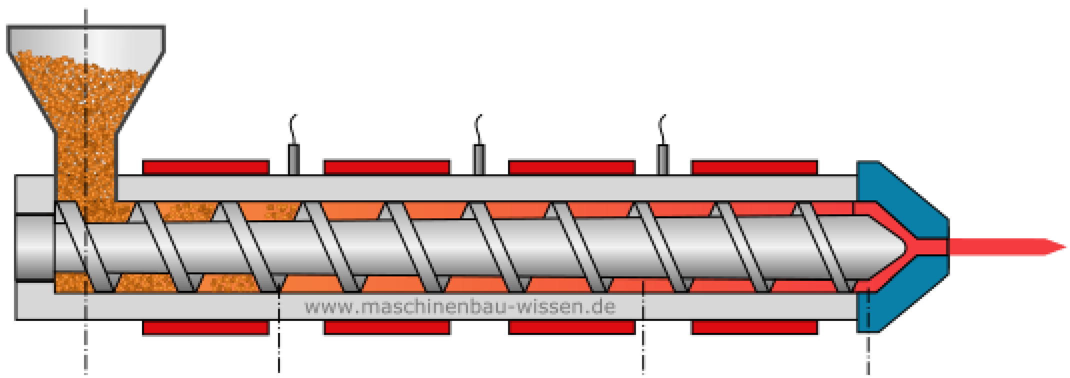




Amarant nişastası

100 MPa, 40°C/10 dak YHB %0.48

600 MPa, 40°C/10 dak YHB %0.55



Ekstrüzyon Uygulamaları

- Ekstrüzyon pişirme, kesme kuvveti, basınç ve ısıtmayı içeren barotermal bir işlemdir.
- Ekstrüzyon ürünlerinin EDN içeriği,
  - beslenen materyalin formülasyonuna (örneğin; nişasta kaynağı, amiloz oranı, başlangıç su içeriği) ve
  - sistem parametrelerine (namlu sıcaklığı, besleme nem içeriği ve besleme hızı, vida hızı ve konfigürasyonuna, namlu çıkış kalıbı çapına) bağlıdır.

Ekstrüzyon pişirme kullanılarak literatürde bildirilen Tip3 EDN içeriğindeki artışlar önemli bulunmamıştır (Sarawong ve ark., 2014; Ai ve ark., 2016).

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Effect of extrusion cooking on the physicochemical properties, resistant starch, phenolic content and antioxidant capacities of green banana flour

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ABSTRACT

Green banana flour was extruded through a co-rotating twin-screw extruder with constant barrel temperature. The objectives of this study were to determine the effect of extrusion cooking variables (feed moisture, FM, 20% and 50%; screw speed, SS, 200 and 400 rpm) and storing of the extruded flours at 4 °C for 24 h on the physicochemical properties, resistant starch (RS), pasting properties and antioxidant capacities. Extrusion cooking at higher FM and lower SS increased the amylose content, which was expressed in highest RS content. Water adsorption index (WAI) and pasting properties were increased, while water solubility index (WSI), total phenolic content (TPC) and antioxidant activities (FRAP, ABTS.$^{+}$, DPPH) in free and bound phenolics were decreased compared to the other extruded samples. Storing the extruded flours at 4 °C for 24 h prior to oven drying was the main factor leading to a further increase in the content of amylose, RS, TPC and WSI values, as well as pasting properties – in particular peak viscosity. Compared to native banana flour, extrusion cooking caused significant changes in all studied properties of the extruded flours, except for soluble DF and antioxidant capacity (ABTS.$^{+}$ and DPPH) of bound phenolics.

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Table 1
Amylose, RS contents, IDF, SDF, and TDF of extruded and native green banana flours stored at 4 °C for 0 and 24 h.

Treatment	Amylose (%, w/w)	RS (%, DM)	Dietary fibre (%, DM)
			IDF
Native flour	16.20 ± 0.86f	47.25 ± 2.15a	4.46 ± 0.16c
Extruded flour[a]			
(1) 20%, 200 rpm, 0 h	17.96 ± 0.04de	1.20 ± 0.14c	3.97 ± 0.18de
(2) 20%, 400 rpm, 0 h	17.25 ± 0.65ef	0.92 ± 0.12c	3.66 ± 0.10e
(3) 50%, 200 rpm, 0 h	30.16 ± 0.12b	3.82 ± 0.14b	5.37 ± 0.16ab
(4) 50%, 400 rpm, 0 h	24.89 ± 0.81c	3.62 ± 0.11b	5.06 ± 0.14b
(5) 20%, 200 rpm, 24 h	18.92 ± 0.90d	1.34 ± 0.12c	4.03 ± 0.07d
(6) 20%, 400 rpm, 24 h	17.60 ± 0.32ef	1.11 ± 0.06c	3.68 ± 0.17e
(7) 50%, 200 rpm, 24 h	33.49 ± 0.39a	4.00 ± 0.07b	5.49 ± 0.08a
(8) 50%, 400 rpm, 24 h	26.17 ± 0.62c	3.71 ± 0.09b	5.11 ± 0.12b

En yüksek EDN içeriği **%4.00**;

- 130°C namlu sıcaklığı,
- %50 besleme nem içeriği,
- 200 rpm vida hızı ve
- 4°C/24 h depolama neticesinde elde edilmiştir.

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An innovative approach for significantly increasing enzyme resistant starch type 3 content in high amylose starches by using extrusion cooking

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ABSTRACT

In this study effects of extrusion cooking on enzyme resistant starch (RS) formation in high amylose corn starches (Hylon V and VII) and the functional properties of RS preparations were investigated. Native starches were extruded at 50, 60, 70% feed moisture contents, at constant screw speed (100 rpm) and barrel temperature (140 °C). Among these samples, the highest RS contents were observed at 60% feed moisture. Therefore, feed moisture in the second and third extrusion cycles was set at 60%. There were significant increases in RS contents of both Hylon V and Hylon VII after the second extrusion cycle ($p < 0.05$). After the third extrusion, the RS levels reached to 40.0 and 45.1% for Hylon V and Hylon VII, respectively. Substantial loss of birefringence in these samples indicated that the increases in RS were mainly due to RS3 formation. The RS samples produced by extrusion did not have high emulsion capacity, but the ones produced from Hylon VII had high emulsion stability. Although, decreases in L* and increases in b* values of extruded samples were significant as compared to respective native starches, the changes were not substantial. Therefore, their incorporation is not expected to cause major changes in the colour of end-products.

Doğal formda Hylon V ve Hylon VII’nin EDN içeriği sırasıyla %43 ve %53 olarak tespit edilmiştir.

Table 1
Enzyme resistant starch content of Hylon V and Hylon VII samples produced by using extrusion cooking at different feed moisture contents and repeated extrusion cycles.

Hylon V based Samples	RS content (%)	Hylon VII based Samples	RS content (%)
H5C#1-50	27.9 b	H7C#1-50	34.8 b
H5C#1-60	33.7 a	H7C#1-60	39.1 a
H5C#1-70	32.6 a	H7C#1-70	35.8 b
H5C#1-60	33.7 c	H7C#1-60	39.1 b
H5C#2-60	38.1 b	H7C#2-60	44.0 a
H5C#3-60	40.0 a	H7C#3-60	45.1 a

H5 Hylon V; *H7* Hylon VII; *C#1*, *C#2* and *C#3* number of extrusion cycles; *50*, *60* and *70* feed moisture contents; *RS* resistant starch.
Values followed by different letters in the same column are significantly different ($p < 0.05$).

En yüksek EDN içeriği

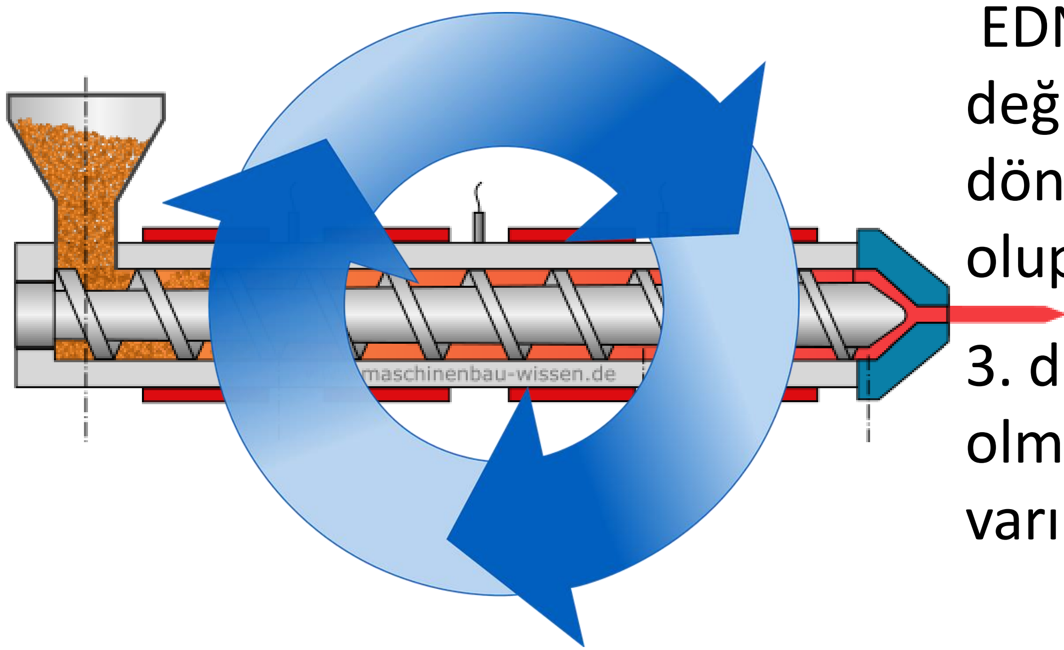
HylonV için %33.7; Hylon VII için %39.1

- 140°C namlu sıcaklığı,
- %60 besleme nem içeriği,
- 100 rpm vida hızında elde edilmiştir.

Table 1
Enzyme resistant starch content of Hylon V and Hylon VII samples produced by using extrusion cooking at different feed moisture contents and repeated extrusion cycles.

Hylon V based Samples	RS content (%)	Hylon VII based Samples	RS content (%)
H5C#1-50	27.9 b	H7C#1-50	34.8 b
H5C#1-60	33.7 a	H7C#1-60	39.1 a
H5C#1-70	32.6 a	H7C#1-70	35.8 b
H5C#1-60	33.7 c	H7C#1-60	39.1 b
H5C#2-60	38.1 b	H7C#2-60	44.0 a
H5C#3-60	40.0 a	H7C#3-60	45.1 a

H5 Hylon V; *H7* Hylon VII; *C#1*, *C#2* and *C#3* number of extrusion cycles; *50*, *60* and *70* feed moisture contents; *RS* resistant starch.
Values followed by different letters in the same column are significantly different ($p < 0.05$).



EDN içeriğinde en yüksek değişim ikinci ekstrüzyon döngüsünde elde edilmiş olup;

3. döngünün ekonomik olmayacağı sonucuna varılmıştır.

Sonuçlar

Tip3 EDN üretimi;

- Jelatinizasyon,
- Dallanma noktalarının kırılması için enzim uygulamaları,
- Sıcaklık-nem uygulamaları,
- Depolama döngüleri

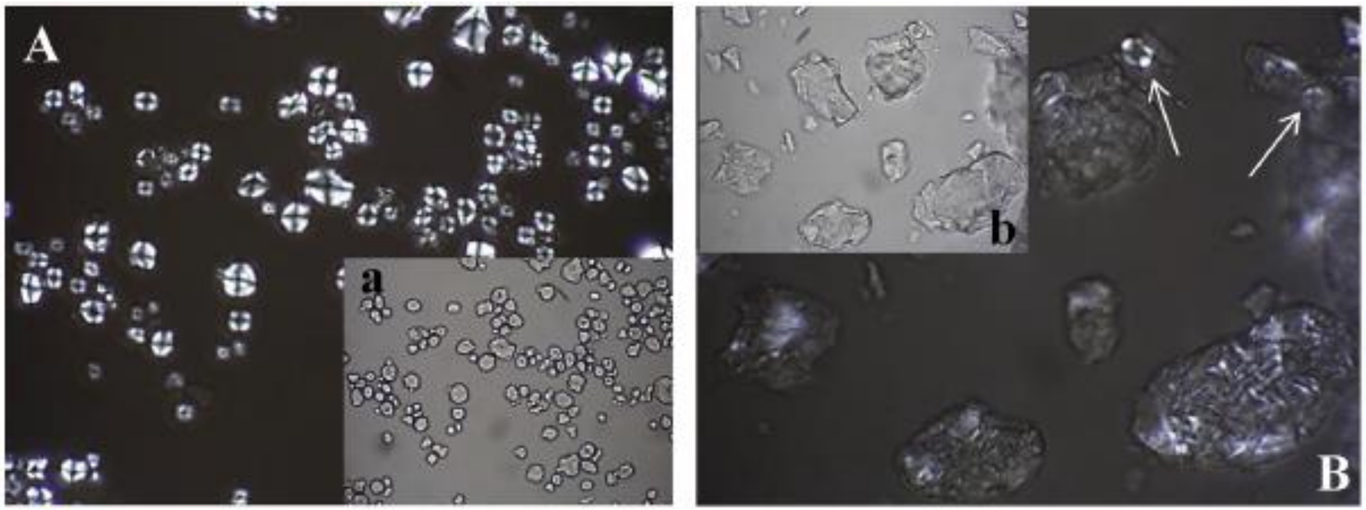
gibi birçok işlem basamağını içermektedir.

Genel olarak değerlendirildiğinde tüm bu işlemler pahalı ve zaman alan proseslerdir. Ekstrüzyon pişirme tekniği ise Tip3 EDN üretimi amacıyla, anılan bu işlemlerin büyük çoğunluğunu bir arada içeren uygulanması kolay bir prosestir.

Literatür incelendiğinde EDN oluşumu üzerine ekstrüzyon işleminin etkisi düşük bulunmuş olsa da;

Bu çalışma ile herhangi bir ön hazırlık (jelatinizasyon, enzim uygulama, depolama vb.) gerektirmeksizin oldukça yüksek düzeylerde (**Hylon V: %40.0; Hylon VII: %45.1**) EDN üretimi gerçekleştirilmiştir.

- Hem Hylon V hem de Hylon VII nişasta örneklerinde, nişasta granüllerinin çoğunluğu ekstrüzyon pişirme işleminden sonra çift kırınım özelliğini tamamen kaybetmiştir.



- Bu da Tip2 EDN'nin geniş ölçüde jelatinizasyonu ve parçalanmasının bir göstergesidir.
- Dolayısıyla, EDN seviyelerinde meydana gelen önemli artışlar esas olarak Tip3 EDN oluşumuna bağlı olmuştur.

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