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08.00.09 Jahon iqtisodiyoti
08.00.10 Demografiya. Mehnat iqtisodiyoti
08.00.11 Marketing
08.00.12 Mintaqaviy iqtisodiyot
08.00.13 Menejment
08.00.14 Iqtisodiyotda axborot tizimlari va texnologiyalari
08.00.15 Tadbirkorlik va kichik biznes iqtisodiyoti
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MUNDARIJA

O'zbekistonda yashil iqtisodiyotni shakllantirishda xitoy va rossiya investitsiyalarining qiyosiy tahlili.....	20
Malikov Numonjon Kamalovich	
Raqamli texnologiyalarning makroiqtisodiy barqarorlikka ta'siri	26
Sherzod Rajabov, Istora Abdusalomova	
Reducing inequality through human capital development: a comparative analysis of policies in the european union and uzbekistan	30
Ilxomjonov Jaxongir Alisher o'g'li	
Hududiy raqamli infratuzilmaning xizmat ko'rsatish sektoriga ta'siri: samarqand viloyati misolida	39
Musinov Dilshod Sultanovich	
Ways to improve quality in hotels through digital technologies	44
N.A. Rakhmonova	
Проблемы и пути внедрения механизма налогового стимулирования центров инновационного роста нового узбекистана.....	48
Умаров Б. С.	
Влияние протекционистской политики на инвестиционные стратегии промышленных предприятий.....	55
Ёдгоров Сардорбек Самадович	
Fiskal siyosat tahlili: aholi bandligi; aholi daromadlari; soliqqa tortish.....	61
Isroilov Boxodir Ibragimovich, Navruzova Farog'at Abdihamid qizi	
Problems in entrepreneurial potential development: a comprehensive analysis of contemporary barriers and challenges	67
Baxtiyor Xabibullayev Abdulvoxid o'g'li	
Tijorat banklarida aholi omonatlarining jozibadorligini oshirishning metodologik asoslari va amaliy yo'nalishlari	73
Xakimov Zoxid Norbo'tayevich	
To'lov aylanmasining mohiyatini aniqlashda to'lov va to'lov oqimlarining roli.....	78
I.F.Sayfiddinov	
Moliyaviy inklyuzivlikni ta'minlovchi samarali soliq siyosati.....	83
Artikov Ne'matulla Abdusalamovich	
Youth, digital finance, and the gig economy in uzbekistan	86
Akmal Boymurodov	
Aktsiyadorlik jamiyatlari korporativ boshqaruvda qaror qabul qilishda raqamli texnologiyalardan foydalanish masalalari	91
Xabibullaeva Shirinxon Tohir qizi	
В условиях трансформации обеспечение развитие образования и нуки в сфере подготовки управленческих кадров	98
Суюнов Дилмурод Холмурадович	
Ипотечное кредитование как инструмент социальной политики в узбекистане	104
Базарова Нигора Равшановна	
Kichik biznes subyektlari tomonidan hudud aholisi bandligini ta'minlashning ijtimoiy va iqtisodiy natijalari.....	110
Ergasheva Nigora Abdigapparovna	
Kichik korxonalar istiqbolli hududlarda sanoat ishlab chiqarish holati dinamikasi.....	114
Xonto'rayev Obbosxon Kamolxon o'g'li	
Banklarning aktivlarini daromadliligini oshirish yo'llari	118
Elbusinova Umida Khamidullaevna	



Ekologik omillar o'zgarishining dehqon xo'jaliklari yalpi hosiliga ta'siri	123
Otamurodova Dildora Abdukrimovna	
O'zbekiston tijorat banklarining yashil iqtisodiyotdagi o'rni	128
Eshev Furqat A'zamovich, Ibragimova Feruza Axtamovna, Jumanazarova Malika Baxtiyorovna, Raxmatova Mohina Dilmurod qizi	
Использование интеллектуальных технологий в процессе обслуживания клиентов банка	132
Хашимова Дилёра Пахритдиновна	
Innovatsion faoliyatning moliyaviy rag'batlantirish va boshqaruv samaradorligini belgilovchi omil va jihatlari.....	138
Baxriddinov Nodirbek Zamirdinovich	
Import tovarlari bo'yicha aksiz solig'ini undirishning nazariy asoslari.....	143
Abdurasulov Murodjon Bahrom o'g'li	
Роль цифровых валют центральных банков в модернизации платёжной инфраструктуры: мировой опыт и перспективы Узбекистана	150
Срожиддинова З.Х., Тухтасинова Д.Н.	
Tijorat banklarida chakana to'lov tizimlarini nazariy asosi.....	155
Sultonov Davronjon Rustam o'g'li	
Tikuv-trikotaj korxonalarida raqobatbardoshlikni oshirishda strategik menejmentning roli	161
Mamatraimov Islom Mamanazarovich	
Ta'lim, ekologiya va raqamlashtirish sohalarida bolalar va o'smirlar turizmini integratsiyalash: xalqaro tajribalar va O'zbekiston.....	170
Islomova Dilrabo Salomovna	
Iqtisodiy masalalarni matritsalar nazariyasi asosida modellashtirish va python dasturlash tilida yechish.....	175
Tojiyev Ilhom Ibraimovich, To'rayeva Feruza Dilmurodovna, Namozova Barchinoy G'ayrat qizi, Baxronova Zuhra Otaniyoz qizi	
Pul bozori barqarorligini ta'minlashda tijorat banklarida likvidlikni boshqarish samaradorligi	188
Sattorova Nasiba G'aniyoz qizi	
The role of digitalization of healthcare in the implementation of the safe city project	192
Akbarjon Iminov	
Аутоиммунные поражения центральной нервной системы, возникающие после стрептококковой инфекции	198
Умарова Саодат Сулаймоновна, Нормакматов Бахтиёр Ботиралиевич	
Iqtisodiyotiga yo'naltirilgan investiyalar tahlili.....	204
Namozov Olim Botirovich	
Creating a favorable climate for investment in agriculture	209
U.I.Djumaniyazov, B.J.Mirzaev	
Davlat ishtirokidagi korxonalarni korporativ boshqaruvni xalqaro standartlari asosida takomillashtirish	214
F.Djalilov	
Davlat tibbiyot tashkilotlarida ish beruvchining fuqarolik javobgarligini majburiy su'gurt qilish xarajatlarini hisobi.....	222
Kuliboyev Azamat Shonazarovich	
O'zbekistonda bank operatsion xarajatlari buxgalteriya hisobi.....	227
Qurbonova Sitara Vahobjon qizi	
O'zbekistonda kichik biznes va tadbirkorlik subyektlarini rivojlantirishning strategik yo'nalishlari.....	233
Musayev Ozodjon Shavkat o'g'li	
Пути обеспечения стабильного экономического роста в условиях перехода к зелёной экономике, совершенствования государственной экономической политики и повышения эффективности внедрения принципов цикличной экономики.....	237
Худайбергенова Адалат Неъматуллаевна, Убайдуллаев Сирожиддин Жамшидович, Файзиёва Хамида	



Кудратовна, Эшбоев Миржалол Бахромович	
O'zbekiston sanoatining iqtisodiy holatini baholash	241
Mamanazarov Oybek Shomurodovich	
Maktabgacha ta'limda tayanch kompetensiyalarni shakllantirishda matematika va savod asoslarining didaktik yechimlari.....	247
Mingboyeva Guldorxon Maxmudovna	
Soliq tizimida soliq riskini baholash uslubiyoti.....	252
Nasimov Ravshanjon Azimovich	
Budjetni rejalashtirish tizimida jismoniy shaxslar daromadlari bo'yicha prognozlashni takomillashtirishning metodologik asoslari	260
Babaev Shavkat Bayramovich	
Понятие и сущность денежного потока в системе финансового управления.....	267
Машарипова Шахло Адамбаевна	
Yashil mehmonxonalarda strategik tahlil metodologiyasi	274
Rasulova Nigora Yusupovna	
Цифровая трансформация: новые возможности и современные тенденции в управлении бизнесом и инвестициями.....	279
Баратова Динора Алишеровна	
Mehmonxonalarda xizmat ko'rsatishning sifati va samaradorligini baholash.....	283
Ikromov Akbar Farxod o'g'li	
Модель внедрения open banking в Узбекистане: предложение на основе международного опыта и локальных особенностей.....	288
Камалов Шухрат Камалович, Аскарова Дилором Хожимуратовна, Баходиров Жасурбек Олёрбек ўғли, Маликов Шохрух Шокирович, Тенгелова Фарангиз Мажид кизи	
O'zbekistonda islom moliyasini joriy qilishning yo'llari	295
Ashurbayev Farrux Alisher o'g'li, Tuxsanov Eldor Dilmurod o'g'li	
AQSH tajribasiga ko'ra eksportni iqtisodiy o'sishga tasiri	299
D.E.Qarshiev	
Iqtisodiyotni tartibga solish orqali aholi farovonligini oshirishning ahamiyati	304
Berdibekov A.	
Mamlakat iqtisodiyotini rivojlantirish va aholi moliyaviy savodxonligini oshirishda inklyuziv molianing ahamiyati.....	308
Latipova Shaxnoza Maxmudovna	
Problems of the financial mechanism influence for stable and inertial development of enterprises.....	313
Zaynalov Jakhongir Rasulovich, Alieva Susanna	
Tibbiyot turizmni rivojlantirish va uning salohiyatini iqtisodiy baholashning ilmiy va uslubiy asoslari	317
Vofaxojayeva Dilafruz Marufovna	
Turistik destinatsiyalar va raqamli marketing texnologiyalari orqali turizm barqarorligini transformatsiya qilish	322
Nurmuhammadxon Oppoqonov	
Kichik va o'rta biznes moliyaviy barqarorligining kambag'allikni kamaytirishdagi ahamiyati.....	327
Djamalov Xasan Numanjanovich	
Qoraqalpog'iston respublikasida turizmni rivojlantirishning tashkiliy va iqtisodiy salohiyatini baholash.....	335
Xoshimov Baxrom Baxadirovich	
O'zbekiston turizm sektorida tog' turizmining ulushi.....	343
Alimov Abduvakil Komil o'g'li	
O'zbekiston respublikasida investitsiya faoliyatini moliyaviy boshqarish va bunda xorij tajribasi.....	348
Ismailov Dilshod Anvarjonovich	



Tadbirkorlik faoliyatini samarali boshqarishda raqamli texnologiyalardan foydalanishning holati.....	354
Sattarov Xayrulla Fayzullayevich	
Tadbirkorlik faoliyatida innovatsiyalarni rivojlantirish strategiyasini tanlash va asoslash	358
Shakirova Madinaxon Gafurdjanovna	
O'zbekistonning xalqaro valyuta-moliya tashkilotlari bilan o'zaro hamkorlik aloqalarini mustahkamlash yo'nalishlari.....	362
Gulmurodova Marjona Olimjon qizi, Turg'unova Zohida Shavkat qizi, Umida Yuldasheva	
Jismoniy shaxslarning daromadlarini soliqqa tortish tartibini takomillashtirish.....	367
Bobomurotova Manzura Panji qizi	
Aksiyadorlik jamiyatlari va qimmatli qog'ozlar bozori o'rtasidagi iqtisodiy munosabatlar	372
Berdaliyev Javohir Jahongir o'g'li	
Farg'ona viloyati mahallalarida tadbirkorlikni va hunarmadchilikni rivojlanishi holati tahlili	379
Tuxtasinov Zafarjon Odiljonovich	
Проблемы охраны окружающей среды и формирования «зеленой экономики»	389
Ёдгорова Мухайё Шухратовна, Иминова Наргиза Акрамовна	
The evolution of passenger transport in uzbekistan and its impact on economic growth.....	392
Naubetova Ziyada Niyet kizi	
Davlat tibbiyot tashkilotlarida ish beruvchining fuqarolik javobgarligini majburiy sug'urta qilish xarajatlarining hisobi.....	397
Kuliboev Azamat Shonazarovich	
Jahon sug'urta amaliyotining O'zbekiston sug'urta bozorining rivojlanishiga ta'siri	402
Kuvatova Dinara Anvarovna	
Milliy iqtisodiyotda xorijiy investitsiyalarning ahamiyati va ta'sir mexanizmlari	406
Abdullayev Zoxid Xolxo'jayevich	
Xaridorlar bilan hisob-kitoblar auditida moliyaviy tahlil usullarini qo'llash xususiyatlari.....	411
Sagimbaev Sultanbek Turdibay o'g'li, Sultamuratov Qallibek	
The function and value of commercial banks in fostering capital market growth	416
Isakov Janabay Yakipbaevich	
Raqamli texnologiyalarning korxonalar risk boshqaruvidagi rolini swot tahlili orqali tadqiq etishning ahamiyati	427
Tojimatov Izzatbek Ikromali o'g'li	
Germaniyaning deutsche banki va buyuk britaniyaning barclays banki xizmatlar amaliyoti va uni o'zbekiston bank tizimi faoliyatiga qo'llash yo'llari	432
Raxmatov Temur Sotiboldiyevich	
The state and development trends of business process auditing in joint-stock companies in uzbekistan.....	439
Utegenova Sarbinaz Turdimuratovna	
Mamlaktimizda amaldagi budjetlararo munosabatlarning tartibi hisobi, hamda uning ahamiyati	444
Tuxsanov Eldor Dilmurod o'g'li, Saydullayeva Zeboxon Shukrilla qizi	
Qurilish materiallari sanoatida innovatsion klasterlarni boshqarishni takomillashtirish	462
Xaydarova E'zoza Shukurullayevna, Li Zin Bo	
Barqaror rivojlanish va yashil iqtisodiyotning mamlakatimizda so'nggi yillardagi oshib borayotgan ahamiyati	467
Bahodirova Mohigul	
Conceptual framework for boosting the financial and economic performance of investment projects in industrial enterprises.....	472
Sarriev Kahraman Ramatullaevich	
Bandlik va ayollar tadbirkorligi	477
Ibodullayeva M.S.	



Mamlakatimiz yalpi ichki mahsulotini ekonometrik prognozlash.....	482
A'zamov Musurmon Axmadovich, Islomov Javohir	
Eksport siyosatini tadbirkorlik faoliyati rivojlanishiga ta'siri.....	488
Suvonov Ibrohim Izbosarovich, Abdug'aniyev Murodjon Shavkat o'g'li	
Aholini ish bilan ta'minlashda qishloq aholisini mehnat salohiyatidan foydalanish.....	492
Noiba Qodirova Maxmud qizi	
Yashirin iqtisodiyotni kamaytirishda rasmiy bandlik va moliyaviy munosabatlarni rivojlantirish	497
Xalimbetov Farxad Bagibekovich, Reyimberdiyev Baburbek Adilbek o'g'li	
Analysis of touristic potential and capacity of ecotourism sites	501
Abdurakhmanova Akida Faizulla kizi	
Xorijiy investitsiya ishtirokidagi korxonalarni moliyalashtirishni takomillashtirish.....	509
Salohiddinov Jaloliddin	
Infratuzilma va bozor infratuzilmasi tushunchalarining nazariy tavsifi	516
G'aniyev Botir Baxtiyorovich	
O'zbekiston va xorijiy davlatlarda aksiyadorlik jamiyatlarining qimmatli qog'ozlar orqali kapital yig'ish strategiyalari	520
Dilnozaxon Muxitdinova	
Iqtisodiy inqiroz paytida korxonalarda likvidlilikni boshqarish strategiyalari	527
Abdusalomova Nodira Bakhodirovna, Jabborova Sevinch Xusanovna	
O'zbekistonda islomiy mikromoliyaviy xizmatlar orqali ish bilan bandlikni oshirish istiqbollari.....	532
Mamatkulov Humoyun Bobir-ugli	
Textile enterprises and changing market conditions: integration of demand analysis, trend forecasting and strategic assortment management	536
Ikramova Nodira Burkhon kizi	
Aksiyadorlik korxonalari boshqaruv tizimida korporativ madaniyatni takomillashtirish	540
Umarchodjaeva Muyassarhon Ganievna, Omanova Nargiza Rustam qizi	
Moliyaviy faoliyat natijalari hisobi va auditini takomillashtirish.....	548
Po'latov Xudoyberdi Uktamovich, Abduxoliqov Isomiddin Ikrom o'g'li	
Rivojlangan va rivojlanayotgan mamlakatlarda iqtisodiyotning real sektori korxonalariga kreditlar bo'yicha foiz stavkalariga ta'sir ko'rsatishda markaziy banklarning qayta moliyalash stavkalarining rolini tahlil qilish	553
Jabbarov Eliboy, Abdullayeva Charos Abdullo qizi	
O'zbekistonda qishloq xo'jalik mahsulotlarini qayta ishlashda innovatsiyalarning roli va iqtisodiy samaradorligi	558
Raximov Baxromjon Ibroximovich, Solohiddinov Nuriddin Sirojiddin o'g'li	
Sirkulyar iqtisodiyotni rivojlantirish orqali chiqindilarni boshqarish muammosini bartaraf etish yo'llari.....	563
Narzullayev Elmurod Shuxrat o'g'li, Hamrokulov Ulug'bek Abdurahmatovich	
Korxonani samarali boshqarishni ta'minlash strategiyalari	567
D.Mutalova	
Masofaviy ta'lim platformalarining qiyosiy tahlili va funksional xususiyatlari.....	571
Nabieva Nilufar Nabi qizi	
Raqamli iqtisodiyotning jamiyat hayotiga ta'siri.....	577
Aripova Ziyoda Xayrullayevna, Nurmuxamedova Tursunoy Usmonovna	
Transportda turistik xizmatlarni boshqarish mexanizmini takomillashtirish.....	581
Tuychiyev Anvarjon Muxtorjonovich	
Ipak yo'lining tarixiy madaniy merosi va hunarmandchiligi: dolzarb muammolar va tadqiqot istiqbollari	584
Xushnazarova Maxzuna Gulamdjanovna	



Eksport faoliyatini rag'batlantirishda institutsional va moliyaviy mexanizmlarning roli.....	589
Umarkulov Kodirjon Maxamadaminovich	
Elektron pul evolyutsiyasi.....	595
Marpatov Mavlonxon Dadashevich	
Yashil iqtisodiyotga o'tish jarayonida sanoat korxonalarining roli.....	600
Nasullayeva Yoqutoy Nasim qizi	
O'zbekistonda turizm marketingi va raqobatbardoshligini oshirish	606
Ikramova Nasiba Axmadovna	
Kambag'allikni qisqartirishning zamonaviy yo'nalishlari.....	610
Mirzayev Qulmamat Jonuzoqovich, Shodiyev Fazliddin Qalandar o'g'li	
Jamiyatda imkoniyati cheklanganlarning bandligini ta'minlashning ijtimoiy-iqtisodiy asoslari.....	615
Tilavova Munisa Maxmudovna	
Moliyaviy matematika vositalarining O'zbekiston kredit tizimidagi qo'llanilishi.....	620
Shamsiyeva Nigora Rafiq qizi	
Ecological sustainability in tourism: regional practices and global reflections.....	626
Sayyora Safaeva	
Quyi amudaryo mintaqasida turli darajadagi destinasiyalararo ixtisoslashgan klasterlarni shakllantirish asoslari va ularning o'ziga xos jihatlari.....	631
Doschanov Tangirbergen, Ollanazarov Bekmurod Davlatmurotovich	
Fine dining restoranlarida marketing strategiyalarining shakllanishi va mijoz jalb qilishda ularning ahamiyati.....	641
Jumaniyazova Sarvinoz Mansur qizi	
Soliq to'lovchilarning majburiyatlari bajarilishini kontseptual asoslari va shartlari asoslari xususida.....	644
Abdusherozov Abdullo Baxtiyorovich	
Davlat sektoridagi tashkilotlarda smetalar tuzish tartibi	651
Abdulaziz Norquchqorov Ziyadullayevich	
Качественное развитие рынка труда узбекистана.....	657
Мамадалиева Хафиза Холдаровна	
Kichik biznes subyektlarining aholi bandligini ta'minlash orqali kambag'allik darajasini pasaytirishdagi o'rni.....	664
Maxamadaliyev Boburbek Baxodir o'g'li	
Устойчивое развитие esg-менеджмента: от тренда к фундаментальной стратегии выживания и процветания.....	670
Собирова Нилуфар Бекпулат кизи	
Sirdaryo viloyatida investitsion faollikni oshirishda davlat va xususiy sektor hamkorligi	676
Mamatqulova Muxlisa Komiljon qizi	
Qurilish loyihalarini moliyalashtirishning milliy va xalqaro tajribasi	681
Yashin Iboyev	
Xizmatlar sohasida innovatsion muhitni yaratishning dolzarb masalalari.....	687
Kamoliddin Mamatqulovich Ibodov, Jamshid Abduxaliqovich Xolboyev	
Sanoat korxonalarining raqobatbardoshligini boshqarishda tovar aylanmasi tahlili.....	692
Jumayeva Gulrux Jo'raqulovna	
Xo'jalik yurituvchi subyektlarda innovatsion faoliyatning moliyaviy va boshqaruv hisobini takomillashtirish masalalari	698
Xushvaqtova Nozanin Nurbek qizi	
Effect of processing on nutrients in tomato products.....	706
Ergasheva Muhabbat Komil kizi	



EFFECT OF PROCESSING ON NUTRIENTS IN TOMATO PRODUCTS

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Abstract: The article provides an overview of the technological process involved in the production of tomato paste, focusing on factors that influence its quality and nutritional value. Specific attention is given to thermal treatment techniques such as cold-break and hot-break methods, and the impact of pressure, temperature, and brix level on viscosity and concentration.

Key words: Cold-break, hot-break, heating, boiling, vacuum, concentration, pressure, brix level, viscosity.

Annotatsiya: Ushbu maqolada pomidor pastasi ishlab chiqarish jarayonining mohiyati hamda uning sifat va oziqlik qiymatiga ta'sir etuvchi omillar tahlil qilinadi. Ayniqsa, sovuq va issiq qaynatish usullari, bosim, harorat va brix darajasi kabi texnologik parametrlarning konsentratsiya va yopishqoqlikka ta'siri yoritilgan.

Kalit so'zlar: Sovuq qaynatish (cold-break), issiq qaynatish (hot-break), qizdirish, qaynash, vakuum, konsentratsiya, bosim, brix darajasi, yopishqoqlik.

Аннотация: В статье рассматриваются особенности технологического процесса производства томатной пасты, с акцентом на факторы, влияющие на её качество и пищевую ценность. Особое внимание уделено методам термической обработки — «холодного» и «горячего» разрыва, а также роли давления, температуры и уровня брикса в формировании вязкости и концентрации продукта.

Ключевые слова: холодный разрыв (cold-break), горячий разрыв (hot-break), нагрев, кипячение, вакуум, концентрация, давление, уровень брикса, вязкость.

INTRODUCTION

The tomato is a significant agricultural crop, used both as a fresh vegetable and as a raw material for a variety of processed products such as tomato juice, ketchup, sauces, canned goods, purée, and paste. In developed countries, approximately 80% of fresh tomatoes are converted into processed products. Tomato paste is produced by removing the seeds and skins from tomatoes, followed by cooking and concentrating the pulp for several hours. In some cases, the paste may be sweetened to enhance its flavor. The final product is a thick, dark red concentrate typically made from whole processing tomatoes containing 4.5% to 6.0% tomato solids. In the industry, the measurement of total soluble solids (TSS) is commonly used, which excludes any insoluble components. According to widely accepted market standards, tomato paste must contain a minimum of 14% TSS. The most commonly available type of tomato paste is the “double concentrate,” which has a Brix level between 26 and 28. However, “triple concentrate” varieties also exist, exhibiting Brix levels between 36 and 38. Tomato processing involves a break step that refers to the rapid heating of freshly chopped tomatoes. In the hot-break method, tomatoes are heated to above 90°C, while in the cold-break method, temperatures range between 60°C and 77°C. These thermal techniques significantly influence the final product's color, viscosity, and aroma.

Cold-break typically occurs at 65–75°C, preserving flavor but reducing viscosity. In contrast, hot-break, at ~90°C, deactivates certain enzymes, leading to a thicker product with higher viscosity.

The key distinction between these methods lies in the activity of enzymes such as polygalacturonase, pectin methylesterase, and lipoxygenase, which break down pectin — a natural polymer that holds tomato cells together.

In hot-break processing, these enzymes are inactivated, preserving pectin integrity and yielding a highly viscous product.



In cold-break processing, enzymatic activity remains, leading to pectin degradation and a less viscous paste. However, this method retains more flavor and aroma.

LITERATURE REVIEW

Tomato (*Solanum lycopersicum*) is a globally significant crop rich in vital nutrients, including lycopene, β -carotene, vitamin C, phenolic compounds, and flavonoids. Over the past few decades, researchers have increasingly focused on how industrial processing affects the retention, transformation, and bioavailability of these nutrients. Several studies have highlighted that thermal processing (e.g., boiling, pasteurization, concentration) can lead to both degradation and enhancement of certain nutrients. According to Gould (1992) and Shi & Le Maguer (2000), the heat applied during tomato paste production deactivates enzymes such as polygalacturonase and lipoxygenase, which otherwise degrade cell structure and affect flavor and texture. However, this same heat exposure can lead to the loss of thermolabile nutrients such as vitamin C and some flavonoids. A seminal study by Gartner et al. (1997) demonstrated that lycopene bioavailability increases after heat processing, due to the breakdown of plant cell matrices and conversion of lycopene into the more absorbable cis-isomer form. This finding is supported by Raffo et al. (2002), who observed that the all-trans lycopene content in tomato paste is significantly higher than in raw tomatoes. On the contrary, Dewanto et al. (2002) observed that ascorbic acid (vitamin C) degrades rapidly during prolonged heating, with up to 60% loss in concentrated tomato paste. Similar degradation patterns were reported by Valverde et al. (2001), indicating that pasteurization and vacuum concentration are critical stages where nutrient loss must be managed.

Moreover, Bhandari & Sen (2018) explored the effect of cold-break vs. hot-break processing methods, revealing that hot-break conditions result in higher viscosity and longer shelf-life but are more likely to reduce volatile aroma compounds. In contrast, cold-break methods preserve flavor but allow enzymatic degradation, reducing pectin integrity and leading to lower viscosity. Reyes & Cisneros-Zevallos (2007) further emphasized that phenolic compounds may increase during storage due to the release of bound phenolics, although the initial thermal processing might reduce free phenolic levels. Collectively, these studies suggest a complex interaction between processing parameters and nutrient dynamics in tomato products. The trade-off between nutritional retention and textural or sensory quality remains a central concern in the optimization of tomato processing technologies.

RESEARCH METHODOLOGY

This study utilizes a mixed-methods approach, combining both experimental laboratory analysis and literature review to examine the impact of processing techniques on the nutrient composition of tomato products. The methodology is structured as follows:

Fresh, fully ripened red tomatoes (*Solanum lycopersicum*) were procured from certified local farms to ensure uniformity and quality. The tomatoes were sorted and categorized based on size, ripeness, and absence of physical defects or microbial contamination.

Two common industrial processing techniques were employed for tomato paste preparation:

Hot Break (HB): Chopped tomatoes were heated rapidly to 90–95°C for enzyme deactivation.

Cold Break (CB): Tomatoes were heated moderately at 65–75°C, allowing enzyme activity to persist.

Each processing batch underwent pasteurization, followed by concentration under vacuum to achieve double (26–28° Brix) and triple concentrate (36–38° Brix) levels.

Post-processing, samples were analyzed for the following nutrient parameters using standardized methods:

Lycopene and β -Carotene: Quantified using High-Performance Liquid Chromatography (HPLC).

Ascorbic Acid (Vitamin C): Determined via the 2,6-dichlorophenol-indophenol titration method.

Total Phenolics: Measured using the Folin–Ciocalteu reagent method.

Flavonoid Content: Analyzed spectrophotometrically at 510 nm.

Total Soluble Solids (TSS): Measured using a digital refractometer.

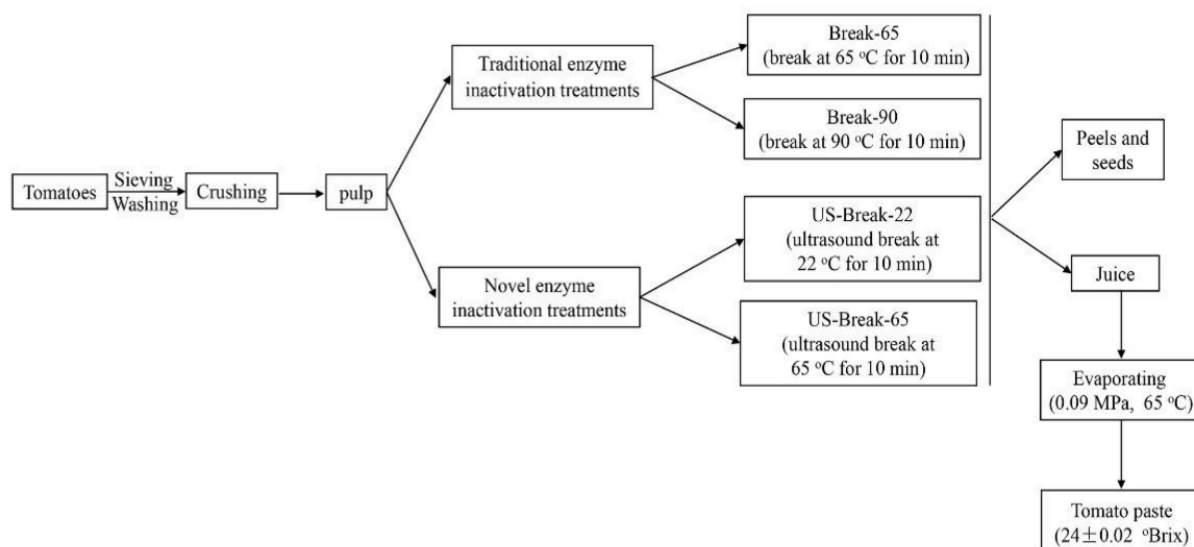
Each measurement was conducted in triplicate for statistical accuracy, and the results were averaged.

In addition to laboratory testing, a comprehensive review of peer-reviewed articles, technological guidelines, and international food processing standards was conducted. Databases such as PubMed, ScienceDirect, and ResearchGate were utilized to cross-verify experimental results and contextualize findings. Collected data were processed using SPSS software (version 25) for descriptive statistics. ANOVA tests were performed to determine the significance of nutrient differences between Hot Break and Cold Break methods, with a significance threshold of $p < 0.05$.



ANALYSIS AND RESULTS

Effects of breaking methods on the viscosity.



The distinction between hot-break and cold-break tomato paste production methods originates from the action of key enzymes: pectin methylesterase, polygalacturonase, and lipoxygenase, which are responsible for the degradation of pectin, a naturally occurring polysaccharide that binds tomato cells together.

In the hot-break method, these enzymes are deactivated or denatured by rapid heating, which prevents pectin degradation and results in a product with higher viscosity. Conversely, in the cold-break method, the enzymes remain active, causing pectin breakdown, which leads to lower viscosity, although this process better retains the natural aroma and flavor of tomatoes. Consequently, the final product is less viscous than that produced using hot-break technology.

Processing also affects the nutrient composition of tomato-based products:

Levels of β -carotene, lycopene, and phenolic compounds increase during thermal processing into value-added products.

The proportion of all-trans lycopene constitutes approximately 96% of total lycopene in preserved tomato paste and 77% in tomato ketchup.

About 65% of flavonoids present in fresh tomatoes are retained after processing into paste.

The total phenolic content in tomato pulp and purée increases during storage due to the release of bound phenolics.

Ascorbic acid losses during processing are estimated at:

40% in tomato pulp

55% in tomato purée

60% in tomato paste

Processed tomato products possess a distinct aroma compared to fresh tomatoes due to the loss and formation of volatile compounds during heat treatment.

To ensure quality retention and nutrient preservation, the following measures should be observed during tomato processing:

Use only fully ripe, red tomatoes that have ripened on the plant. The presence of yellow or green patches may cause oxidation-induced browning and reduce color intensity.

Avoid iron utensils during processing, as lycopene can oxidize and turn brown upon contact with iron. Furthermore, iron can react with tannins and spices to form undesirable black compounds.

Minimize excessive heating and rapidly cool tomato-based products like ketchup, sauces, chutneys, and soups after preparation to preserve flavor and nutrients.

Simple rinsing is insufficient. Microorganisms, including mold filaments hidden in cracks, wrinkles, and stem cavities, cannot be eliminated through water washing alone.

Pasteurize bottled products post-filling to prevent fermentation and microbial spoilage.

To prevent "black neck" formation (dark discoloration in the bottle neck), follow these steps:

Fill bottles at a minimum temperature of 85°C.

Minimize headspace in containers, as excess air increases oxidation risk.



Store bottles horizontally or upside down to evenly distribute trapped oxygen (O_2), thereby reducing its concentration at the neck and minimizing discoloration.

Reduce iron contamination, which can come from metal equipment or salt used during processing.

Partially replace sugar with corn syrup or glucose, which contain sulfur compounds that help prevent darkening.

Optionally, introduce 100 ppm of sulfur dioxide or 100 mg% ascorbic acid as preservatives and antioxidants.

CONCLUSION AND SUGGESTIONS

Tomato paste production may seem complete and relatively simple to carry out. However, there are numerous critical micro-processes and parameters that require careful monitoring in order to achieve high-quality tomato paste. The Cold Break and Hot Break methods may appear trivial at first glance. Nevertheless, in the Cold Break process, the enzymes pectin methylesterase and polygalacturonate remain active, as they are not subjected to deactivation. This results in lower viscosity levels compared to Hot Break methods but offers advantages in preserving the natural flavor and aroma of the final product.

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