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An Investigation into Audio Quality of Streaming Services: Do Music Consumers Get the Audio Quality They Pay For?*

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Abstract

The digitization of the music industry has transformed both the production and consumption of music globally, leading to a more accessible and convenient environment through mobile music streaming services. Service providers have developed premium packages that offer enhanced audio quality and additional features. However, previous studies have found out that individuals are often unable to perceive differences in audio quality across various listening environments. Consequently, there exists a possibility that service providers might not be delivering the pledged audio quality, and customers may remain oblivious to this issue. This study aims to examine the validity of service providers' claims regarding the audio quality provided through premium services, and investigate whether music producers and artists are allowed to upload low-quality audio files without restrictions and control mechanisms. The study focuses on two of the most widely used global music streaming service providers: Spotify and Apple Music. The results of the study indicate that the premium options of these platforms

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do not always deliver the promised audio quality, and low-quality sound files can be uploaded without being detected by musicians or customers. As a result, customers are paying for premium services despite not receiving the full benefits promised with respect to audio quality.

Key words: Music streaming services, premium services, audio quality, consumer perception, control mechanisms.

Streaming Hizmetlerin Ses Kalitesine İlişkin Bir İnceleme: Müzik Tüketicileri Ödediklerinin Karşılığını Alabiliyor Mu?

Özet

Müzik endüstrisinin dijitalleşmesi, müziğin hem üretimini hem de tüketimini küresel olarak dönüştürmüş ve mobil müzik streaming hizmetleri aracılığıyla daha erişilebilir ve kullanışlı bir ortama yol açmıştır. Hizmet sağlayıcılar, gelişmiş ses kalitesi ve ek özellikler sunan premium paketler geliştirmiştir. Bununla birlikte, önceki çalışmalar, bireylerin çeşitli dinleme ortamlarında ses kalitesindeki farklılıkları algılayamadıklarını ortaya koymuştur. Sonuç olarak, hizmet sağlayıcıların taahhüt ettikleri ses kalitesini sunmama ve müşterilerin de bu konudan habersiz kalma ihtimali bulunmaktadır. Bu çalışma, hizmet sağlayıcıların premium hizmetler aracılığıyla sağlanan ses kalitesine ilişkin iddialarının geçerliliğini incelemeyi ve müzik yapımcıları ile sanatçıların kısıtlama ve kontrol mekanizmaları olmaksızın düşük kaliteli ses dosyaları yüklemelerine izin verilip verilmediğini araştırmayı amaçlamaktadır. Çalışma, en yaygın kullanılan iki küresel müzik streaming platformuna odaklanmaktadır: Spotify ve Apple Music. Çalışmanın sonuçları, bu platformların premium seçeneklerinin her zaman vaat edilen ses kalitesini sunmadığını ve düşük kaliteli ses dosyalarının müzisyenler veya müşteriler tarafından tespit edilmeden yüklenebildiğini göstermektedir. Sonuç olarak, müşteriler ses kalitesi açısından vaat edilen tüm faydaları elde edememelerine rağmen premium hizmetler için ödeme yapmaktadır.

Anahtar kelimeler: Müzikte Streaming hizmetler, premium hizmetler, ses kalitesi, tüketici algısı, kontrol mekanizmaları

Introduction

The advancements in real-time data streaming technology have revolutionized the

distribution of audio and video content over the internet. With its ability to reach a vast audience, real-time and wireless video / audio streaming has become predominant components in internet data flow. The proliferation of internet-connected devices, such as TV sets, video players, computers, tablets, and smartphones, has made it increasingly convenient for users to access and enjoy music and video content through streaming services. The decline in interest in phonogram products and the widespread adoption of high-speed internet access have also driven a shift in music listening habits toward streaming-based platforms, as users opt for the ease and convenience of accessing music on-demand without the need for storage or downloads.

According to West (2014), the acceleration of data rates has played a crucial role in the widespread acceptance of real-time streaming technology. In recent years, streaming technology has become an integral part of daily life, with its various applications. The low cost of internet access and the increased popularity of portable smartphones have further contributed to the popularity of streaming services, thereby transforming the way people consume and experience music. The study by Barata & Coelho (2022) confirms the impact of these developments on music listening habits, highlighting the significant change brought about by real-time streaming technology.

Despite this progress, the growth of music streaming services has been able to compensate for the decline in physical sales, with approximately $26 billion in total sales in 2021, surpassing the 1999 peak of $24 billion. However, 2021 digital sales still lag behind 1999 physical album revenues by $3 billion when the $5 billion in physical revenues of 2021 is subtracted from the total amount (IFPI, 2022). This shows that there is still progress to be made in the digital music industry.

Additionally, with the increasing number of service providers in the digital space, choosing between service types has become a crucial issue for consumers. This highlights the importance of service quality, which has been shown to positively influence the adoption of digital services including music streaming services. However, during the industry's shift towards streaming services in the last decade, the impact of audio quality on customer experience and purchasing behavior in this context has been largely neglected.

In light of this, a three-step study was conducted to examine the effect of audio quality on purchasing behavior. The study consists of a literature review, interviews with industry professionals to identify potential audio quality problems in music streaming services, followed by two technical analyses that incorporate the insights obtained from the interviews as a starting point. The initial technical analysis has focused on examining the existence of audio quality control mechanisms for songs uploaded to the streaming platform by artists and producers. Subsequently, the second analysis has assessed the audio quality of tracks that were already present on the platforms.

Literature Review

In this section we will explore the evolution of Digital Music Services (DMS) globally and specifically in Turkey, tracing their development from their early stages to the common streaming platforms we know today. We will also look briefly into the contrasting strategies employed in the pre-2000s era and those shaping the industry today.

Development of Digital Music Services in the World and in Turkey

Since late 90s, the advent of the internet has caused a radical shift in the production, distribution, and consumption of music. The emergence of platforms such as Napster and Kazaa, which allowed consumers to easily share MP3 files with each other using peer-to-peer network technology (Vaccaro & Cohn, 2004), has led to a significant and rapid decline in physical sales, once the primary revenue channel for recorded music (IFPI, 2022). While the International Federation of the Phonographic Industry (IFPI) won lawsuits against these platforms, no increase in physical revenues was achieved as new consumer behaviors evolved toward digital music consumption. Traditional record companies struggled to adapt to the new landscape and introduce new business models, while technology companies have pursued various strategies.

In April 2003, Apple launched its iTunes service and achieved significant success, as evidenced by 14 million downloaded songs in the first six months, a figure that surged to 100 million by July 2004 (Vaccaro & Cohn, 2004). Despite this accomplishment, music companies continued to experience losses until the advent of Spotify's software application, which featured a new service model based on streaming technology and was made available on the Apple App Store. Subsequently, in 2010, the US music industry's total revenue began to experience growth for the first time in a decade (Figure 1).

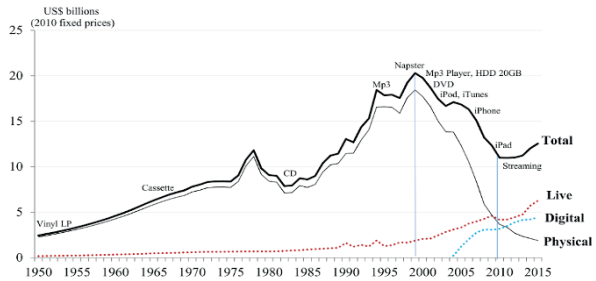


Figure 1: US music industry revenues based on Pollstar and RIAA, 1950-2015 (Naveed, Watanabe, & Neittaanmaki, 2017)

The global recorded music industry experienced a decline in total revenues until 2014, as depicted in Figure 2. However, a remarkable resurgence ensued, culminating

in sales surpassing the peak sales amount of 1999 by 2021. This revival was driven by music streaming revenues, which constituted around 65% of the total sales, yielding $16.9 billion in revenue. Additionally, the physical sales category saw a rise for the first time since 2001, aided by a surge in vinyl sales by collectors. However, this only accounted for 19.2% of the total sales.

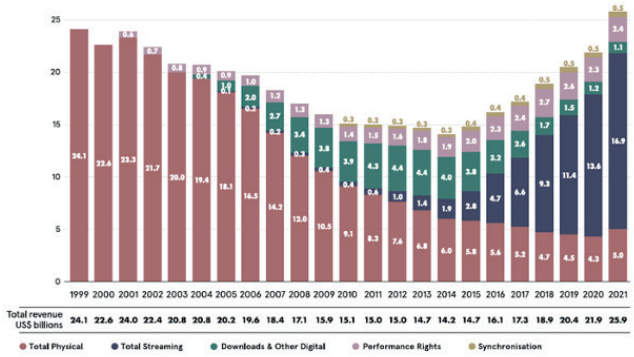


Figure 2. Global music revenues, US$ billions, 1999-2021 (IFPI, 2022)

According to Figure 3, subscription-based music streaming services accounted for 47.3% of the total music sales, while ad-supported streaming accounted for 17.7%.

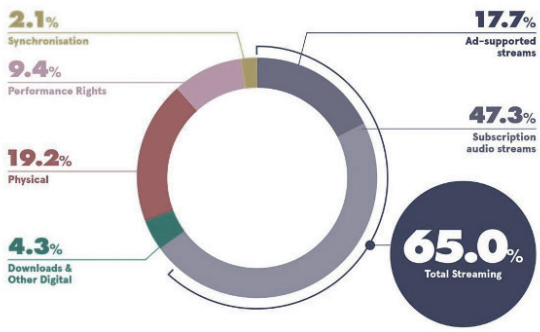


Figure 3. Global music revenues by segment, 2020-2021 (Broom, 2022)

Since its launch in 2008, Spotify has experienced significant growth in active users, from 15 million in 2012, to 100 million in 2017 and approximately 525 million in the first quarter of 2021, with an increase of 26.4% due to the addition of 109.5 million new subscribers over the previous year (Mulligan, 2022; Aguiar & Waldfogel, 2018). In terms of global market shares, Spotify (31%) leads the music streaming platforms, followed by Apple Music (15%) and Amazon Music (13%).

The digital transition of the Turkish music industry lagged behind global trends.

However, in the mid-2000s, MU-YAP (Phonogram Producers Collecting Society of Turkey) initiated significant efforts to catch up. Music services were launched, which enabled users to download music to their phones in various forms such as "Ring Back Tone" via Internet Service Providers (ISPs). The success of these applications prompted GSM operators to introduce "Real Tone". In 2005, MU-YAP developed this application, which contained a digital collection of about 70,000 popular musical works, resulting in a three-fold increase in revenue from the previous year (Saka, 2019). MU-YAP also signed an agreement with Orchard, which has one of the largest digital distribution networks worldwide, to provide the iTunes Store, the most extensive music marketing and sales platform at that time, albeit later than its global peers, with an extensive musical archive.

Analysis of digital sales from 2016 to 2020 has revealed that revenues from streaming services surged from $8 million to $43.1 million, a fivefold increase (Spotify, 2024). Subscription-based audio streaming services like Spotify contributed $29.5 million to streaming revenue, while ad-supported audio streaming systems and video streaming systems accounted for $5.2 million and $8.3 million, respectively. Despite the declining physical revenues, the total sales rose from $21.6 million to $55.4 million, reflecting a remarkable growth rate of 156.4%. Table 1 provides a detailed breakdown of revenues by type and year.

	2016	2017	2018	2019	2020
Streaming	8	12.8	17.5	23.9	43.1
Download and Other	1.2	0.9	0.5	0.4	0.4
Physical	6.5	6.2	5.7	3.9	3.5
Performance	5.6	5.2	5.8	7.2	7.5
Synchronization	0.3	0.5	0.6	1	0.9
TOTAL	**21.6**	**25.6**	**30.1**	**36.4**	**55.4**

Table 1. Total phonogram revenues in Turkey, $ million, 2016-2020 (Spotify, 2024)

In the past, early music platforms such as PowerClub and Muzi were followed by TTnet music, AVEA music, and GNC play in Turkey, and the sector has gained significant popularity with the launch of the iTunes Store. However, with the increasing popularity of global streaming platforms like Spotify and Apple Music, many of these local platforms have either gone bankrupt or changed their names. Fizy founded in 2007 and acquired by Turkcell and Muud – the renamed version of TTnet music constitute the two important local platforms in Turkey.

The Promised Quality of Music Streaming Services and Perceivability

The promise of high audio quality is a key feature offered by service providers such as Apple Music and is highly valued by consumers (Morris & Powers, 2015). While some innovative services, such as DJ mode, artist shopping experiences, and spatial sound, have emerged on music streaming platforms as of 2021 (DIMA, 2022), the use of audio quality and codecs as a marketing tool remains prevalent. Apple's recent announcement of lossless audio for its Air Pods (headphones) is an example of how audio quality is communicated to consumers, as shown in Figure 4.

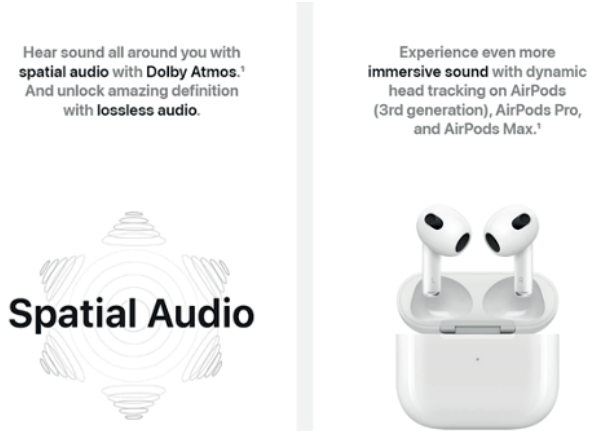


Figure 4. Apple introducing lossless audio (Apple, 2022)

Figure 5 displays the audio quality options offered by Spotify in the settings section, including low, normal, and high-quality settings.

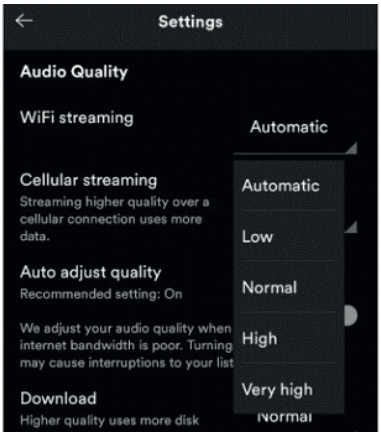


Figure 5. Spotify audio quality settings (Spotify, 2023)

The algorithms used in compressed files reduce the size of the audio file by eliminating frequencies that are not perceived by the human ear. However, they can also introduce artifacts, subtle deteriorations, distortions, and unwanted sounds into the audio. However, early tests have shown that not every listener perceives these distortions, and there are different studies on whether they are perceived or not. These compression formats, often considered among the most important added values of streaming services, can be difficult to understand, especially for listeners and industry professionals who generally use high-fidelity equipment. Factors such as the listening environment, the equipment used, and personal sensitivity play important roles in determining whether these differences or distortions are perceived or not.

Considering that many listeners use smartphones and headphones today, perceiving the quality of a compressed format seems quite difficult. Nevertheless, streaming platforms continue to promise high quality to premium users, and some even offer archives containing completely lossless high-quality audio files, ignoring storage space and download speed limitations, which creates an important marketing strategy and thus an opportunity to gain new users.

The transmission of digital data is a critical consideration in the era of digitalization. Various audio file formats have been developed and are still evolving for data transfer purposes. Therefore, understanding the significance and position of the most widely accepted audio formats is vital for comprehending audio streaming quality. In this regard, next section provides an overview of quality components such as audio formats, codecs, and sound quality analysis methods.

The Technical Dimension of Audio Quality

In terms of preservation, audio formats can be classified as either compressed or uncompressed. Uncompressed, or lossless audio formats maintain the original quality of the digitized audio by preserving the data without any compression (Behl, Audio Formats, Characteristics and Deterioration, 2015). While mainly used in industry, these formats are also utilized by consumers. The earliest example of an uncompressed format is the Waveform Audio (WAV) format, which was developed by Microsoft and IBM for Personal Computers (PCs). The second most widely used uncompressed format is the Audio Interchange File Format (AIFF), developed by Apple.

Compressed audio files, as the name suggests, are files that have been compressed and therefore, exhibit a certain degree of loss in sound quality (Firmansah & Setiawan, 2016). Despite this fact, they are commonly used to reduce the size of the audio data, which in turn reduces the file size. Certain non-essential audio data that would not typically be noticeable to the human ear is excluded in the compression process. As a result, when these files are listened to by non-experts, the reduction in audio quality is not easily discernible (Lopez, Before you pay for high-fidelity streaming music, try to pass this lossless audio test, 2021). Hence, the considerable reduction in file size justifies the minor compromise in the form of a slight decrease in audio quality, and

ensures that these files become readily usable in audio streaming applications.

One popular compressed audio format developed by the Moving Pictures Experts Group (MPEG) is the MPEG-1 Audio Layer III (MP3) format that is capable of reducing file size by up to 90% (Pan, 1995). It is widely used and supports many digital applications. The most common version of MPEG is the MPEG1 Audio Layer3 (mp3) format. In contrast, the Ogg-Vorbis format is an open source and patent-free compression format that has emerged as an alternative to mp3 (Moffitt, Ogg Vorbis—open, free audio—set your media free, 2001). It is the preferred format of Spotify. Another compression algorithm, designed by Apple as an alternative to mp3, is the Advanced Audio Coding (AAC) format (Herre, J.; Schultz, D., 1998).

Audio codecs are an additional component that plays a significant role in sound quality, in addition to audio compression formats. Codecs are sets of algorithms used to encode or decode a data stream or signal (Jayant & Noll, 1984). High-quality algorithms used in codecs can increase the speed of data transfer, leading to savings in data band capacity. Audio codecs enable the decoding of compressed audio files in real-time, allowing for greater performance of computer components in terms of data storage space and processor, and ensuring usability across different platforms.

In the context of quality audio coding, the sample rate is an important consideration that extends beyond just the encoding and decoding process. Sample rate refers to the frequency at which audio data is recorded per second (Lévesque, 2014; Watkinson, 2013). It is typically measured in hertz (Hz) or kilohertz (kHz). A standard sample rate is 44,100 samples per second, represented as 44,100 Hz or 44.1 kHz. The higher the sample rate is during the digital recording of sound, the more accurately the generated sound data will represent the original sound. In other words, when played through a software application, the sound produced will be a close approximation of the original recording.

The second dimension of audio quality when sampling is bit depth, which represents the number of data bits per unit of audio sampling (Brown, 2021; Ciesla, 2022). Similar to the sampling rate, a higher bit depth more accurately represents the actual sound source. A higher bit depth allows for a wider range of volume levels to be captured. For instance, a CD with 16-bit depth can represent 65,536 different volume levels, while an 8-bit recording might only capture 256 levels, potentially leading to noticeable jumps in volume.

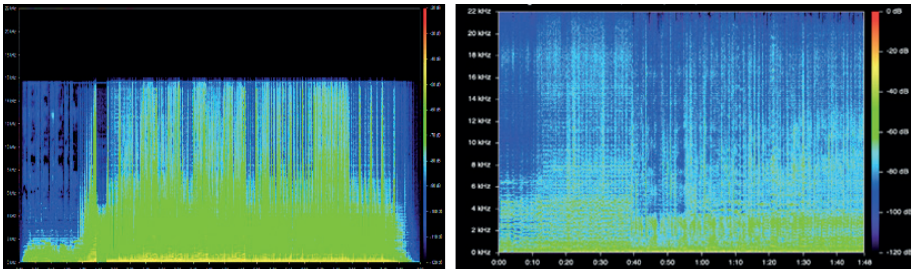
Bit rate is an important quality measure in compressed audio formats, as it represents the amount of data that can be processed in a given time (Burns, 2020; Lavry, 2004). Units such as Kbps and Mbps are used to express the bit rate. However, high bit rates alone do not guarantee high quality; other factors such as internet speed also need to be considered. Nonetheless, higher bit rates provide a better streaming experience.

Bit rate variation in encoding standards is not necessarily constant and may vary according to encoder preferences (Rashid, 2021; Camberlein & Philippe, 2005):

- Variable Bit Rate (VBR): Different bit rates are used to encode audio in complex areas that require more data. Although the encoding time is long, VBR offers a relatively good quality/storage ratio.
- Average Bit Rate (ABR): It is a subcomponent of VBR. The encoder achieves both lower and higher bit rates, creating an average bit rate.
- Constant Bit Rate (CBR): Keeps the bit rate constant throughout playback. CBR generally encodes faster than VBR but takes up more space.

The audio spectrum analyzer, also known as a spectrometer, is a tool that facilitates the visualization and analysis of frequency components within a sound recording over a given time period. Figure 6 depicts an image of a musical piece encoded at a fixed bit rate of 128 Kbps as displayed on the spectrometer. Variables that are on the left y-axis represent the frequency measures, while the sound intensity, measured in decibels (dB), are located on the right y-axis as a color chart. A gradual color gradient from blue to red is employed on the color chart, with blue hues corresponding to lower sound intensities and red hues corresponding to higher intensities. The x-axis displays the temporal progression of the selected audio.

In audio recording analysis, the bit rate of a recording can be estimated approximately by observing the intensities of the sound in the time and frequency axes. The horizontal axis of the spectrum analyzer indicates the time interval, while the vertical axes represent frequency and sound intensity (decibel-dB), respectively. By observing the frequency range in the graph where it cuts off, the bit rate of the recorded audio can be estimated. For instance, a cut-off at 11 kHz indicates a bit rate of 64 Kbps, while a cut-off at 16 kHz indicates a bit rate of 128 Kbps. Similarly, a cut-off at 19kHz suggests a bit rate of 192 Kbps, and at 20kHz, a bit rate of 320 Kbps. Finally, a cut-off at 22 kHz implies a bit rate of 500 Kbps.



Cut at 16kHz indicating 128 kbps *Cut at 22kHz indicating a bit rate at 320 to 500 kbps*

Figure 6. A 128 Kbps CBR audio file vs a 320 Kbps CBR Audio file

In the absence of interruption, bit rates are higher than 1,000 Kbps and indicate a lossless audio format (such as WAV, FLAC). In Figure 6, the frequencies are cut off

around 15kHz to 16kHz, indicating an approximate bit rate of 128 Kbps and cut off at 22 kHz indicating a bit rate of 320 to 500 Kbps for the analyzed audio. Figure 7, on the other hand, shows the use of variable bit rate (VBR), with different frequency peaks appearing at different time intervals. Despite being recorded at 256 Kbps, the recording exhibits frequency increases up to 20-21 kHz, indicating the possibility of a high-quality sound recording originating from the original studio recording.

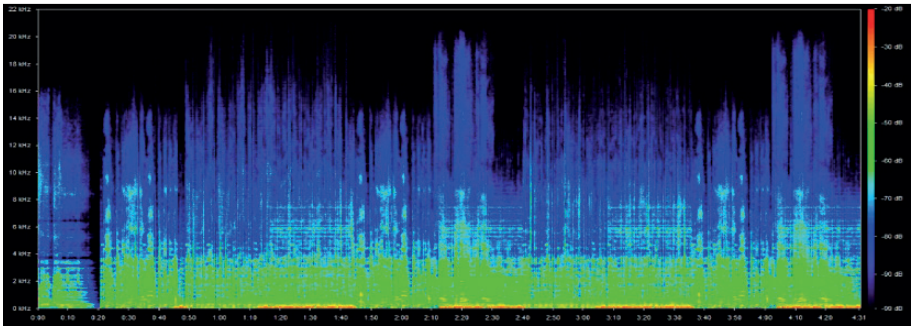


Figure 7. A 256Kbps VBR audio file

Hypothesis Development

Prior to conducting technical studies, consultation with industry professionals was undertaken to gain insight into the audio quality of music streaming platforms, with particular attention given to the integration of catalogs of Turkish record companies. MU-YAP, which had established a digital music market by collecting all the music catalogs of its members into a digital database in collaboration with various platforms in the early 2000s, was initially contacted to seek information from industry experts. As a result, in 2022 an interview was conducted with Metin Uzelli, the person entrusted by MU-YAP to upload the collective music archive and also the proprietor of Uzelli Kaset. Uzelli Kaset serves as the Turkish distributor of The Orchard, one of the prominent companies in the global digital music distribution industry.

Metin Uzelli has acknowledged that in early 2000s the creation of the digital database was problematic, and many works were inaccessible, with a significant portion of the accessible ones having poor sound quality. During that era, the internet bandwidth and speed were inadequate, and there were insufficient human resources and time to meet today's standards for the mass digital archive upload. It was predicted that issues with the sound quality of this collectively created database could arise, given the internet bandwidth, download, and upload speeds that were available during that time.

In the context of music streaming platforms, it is possible for low-quality audio files to be uploaded and distributed without a proper audio quality check, while appearing to meet the file and data type requirements. For instance, an mp3 file with a

128 Kbps resolution may be upgraded to meet the system's audio file requirements and create a 24bit 44.1kHz audio file, without any actual increase in audio quality.

Two hypotheses were formulated based on literature research and preliminary interview:

H1: Music streaming platforms consistently deliver the audio quality promised for all content.

H2: Music streaming platforms conduct adequate audio quality checks on all uploaded songs, in accordance with the audio quality standards they have promised.

To test these hypotheses, five different technical analyses were performed on a random selection of musical works, and the results are presented in the subsequent sections.

Various Technical Analysis on Audio Quality of Streaming Services

To perform five separate technical analyses, a collection of one hundred Turkish songs was randomly selected from MU-YAP's original digital collection, which was established and provided during the early 2000s for distribution through digital channels. Lossless audio formats from the original CDs were acquired for comparison with the audio versions available on Spotify and Apple Music.

Study 1: Comparison of Bit Rates Over Wi-Fi and Cellular Data

The objective of this study is to examine whether the bit rate, a significant factor in determining the audio quality of musical works on streaming platforms, varies between cellular data and wireless network (Wi-Fi) usage. To achieve this, the bit rates of musical works were measured separately with cellular and wireless data usage and then compared with the lossless audio formats on the original CDs of the musical works. The frequency analyses conducted on the musical works provided by all streaming providers revealed that there were no significant differences between the lossless audio formats of musical works and audio formats delivered over cellular and wireless networks.

Study 2: Comparison of Bit Rates in Mobile and Desktop Applications

The objective of this study is to investigate potential differences in bit rates between the mobile and desktop versions of audio streaming platforms. To achieve this, analog signals from mobile phones were converted to a digital format by using a headphone output → 1/8-inch TRS Y cable → Preamp → Digital Audio Workstation (DAW) instrument input signal line. Although background noise occurred during the signal transfer and analog/digital conversion process, it was detected in the spectrum analyzer and eliminated from the original audio file. To achieve this, the noise was recorded while no signal was being transmitted, and X-Noise of Waves Audio software was trained to remove the noise from the transmitted signals.

The frequency analysis results indicated that the mobile and desktop versions of

music streaming platforms provided similar frequency graphs for the musical works. In other words, the frequency spectra of the audio formats available on both platforms were nearly identical; it is understood that desktop and mobile applications broadcast consistently with each other.

Study 3: Comparison of audio file created by compression of lossless format on CD and compressed audio files uploaded to music streaming platforms.

The aim of this study is to investigate the consistency of lossless audio obtained from CDs and compressed via codecs with audio files obtained from streaming service applications. To this end, the original CD audio file was directly converted to AAC and Ogg-Vorbis formats and compared with the corresponding audio files from the streaming applications.

During critical listening sessions, technical aspects of sound including frequency response, dynamic range, tone, and instrument cohesion were examined to determine whether any significant differences exist between lossless audio ripped from CD and compressed through codecs, and audio files obtained from streaming services. The spectrum analysis conducted revealed that musical works provided by Spotify and Apple Music with bit rates of 256 Kbps and 320 Kbps, respectively, exhibit consistency with musical works created by using codecs from original files. The analysis of the Y-axes on the left side of the graphs (data rates reaching 21 to 22kHz for Spotify and Apple Music) indicates a match between the audio files extracted from CD and the streaming services' audio files generated with their own codecs.

Study 4: Examination of compressed audio files provided to streaming platforms before 2005 in Turkey.

Based on the data gathered from one-to-one interviews with music industry experts, this study investigates whether the Turkish-origin repertoire uploaded to streaming service platforms prior to 2005 falls short of the audio quality promised by these platforms. To assess the audio quality of a representative sample of this repertoire, 20-30 second sections of randomly selected tracks were extracted and subjected to frequency analysis. To achieve this lossless process, various songs or audio samples were recorded into a digital audio workstation (DAW) while being played on a streaming platform application on a computer. This was done using a digital converter application, such as Soundflower or BlackHole. Soundflower and BlackHole are free, open-source tools for Mac that function as virtual audio devices. These applications allow audio output from one application to be routed as input to another application.

Figure 8 presents a comparative spectrum analysis of 13 Turkish-origin tracks obtained from Spotify, revealing visible differences in frequency (Kbps) between the musical pieces, some of which feature frequency cut-off below 16 kHz.

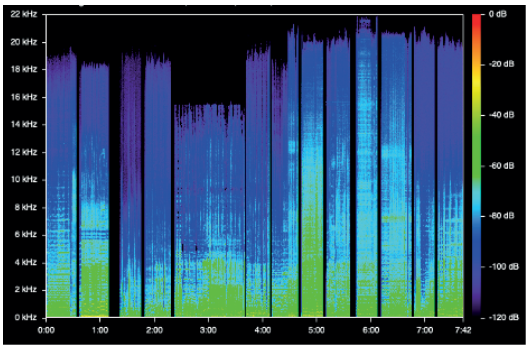


Figure 8. 13 Turkish songs randomly selected from the Spotify repertoire from 2005 and earlier.

Similarly, to Spotify, the spectrum analysis of 16 Turkish songs selected from Apple Music also reveals significant differences in bit depth and bit rate. The analysis shows cut-offs around 9 kHz to 10 kHz, which correspond to a bit rate even lower than 128 Kbps. This cut-off point corresponds to a bit rate of 64 Kbps, falling below the lowest quality standard accepted today. This suggests that the lower quality audios in the Turkish-origin repertoire were possibly uploaded to the system prior to 2005.

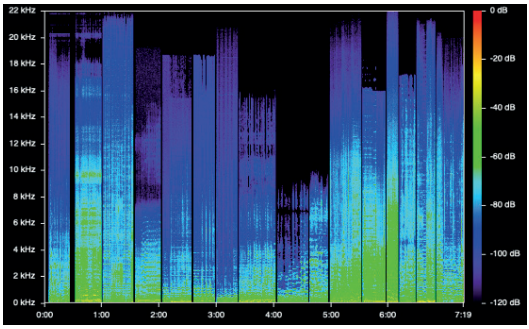
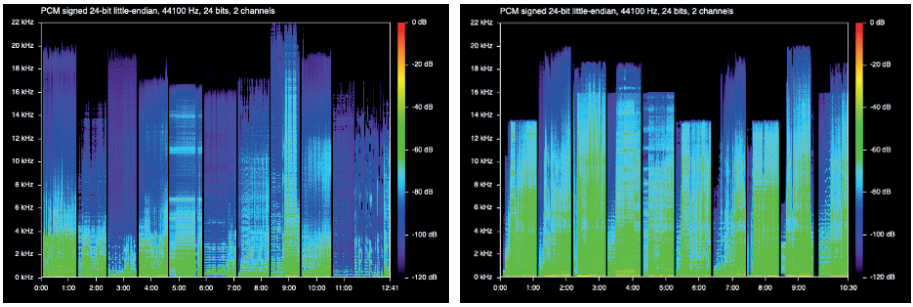


Figure 9. 16 Turkish songs selected randomly from Apple Music repertoire from 2005 and earlier.

Based on this research, albums and songs uploaded before 2005 were prioritized, and a large number of samples uploaded in poor quality from various years were detected. The selection process for analysis, prioritized musicians who retain their popularity. Low-quality samples have been discovered on the albums of Tarkan, Sezen Aksu, İbrahim Tatlıses, Fazıl Say, Sertab Erener, Fikret Kızılok, Cem Karaca, and many more popular Turkish music artists.

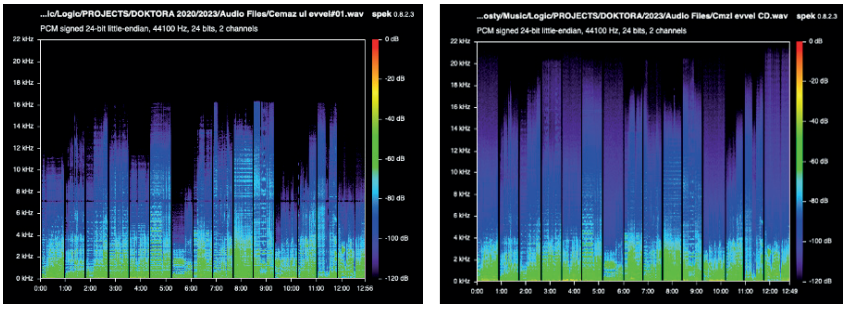
Figure 10 depicts a spectrum analysis of Cem Karaca's and Tarkan's top ten songs based on Spotify data, revealing that nearly half of Cem Karaca songs have poor sound quality. The extremely low sound quality in the albums of Tarkan, still one of the most popular and one of the world-famous artists in Turkey, is striking.



Cem Karaca *Tarkan*

Figure 10. Spectrum analysis of top 10 songs of Cem Karaca and Tarkan, according to Spotify data.

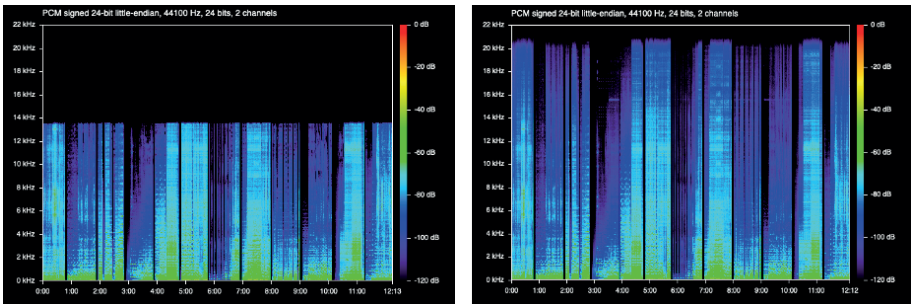
In order to determine whether the audio quality issues originated during the upload to the streaming platform or were present in the original CD edition, the audio spectrograms of the audio files from the original CD and the corresponding versions on Spotify were compared. The results for Cem Karaca are shown in Figure 11. Spotify / Original CD contents were given respectively to the sound analysis of 15 songs in Cem Karaca's album Cemaz ül Evvel and it was observed that the audio files on the CD were generally of high quality.



Spotify *Original CD*

Figure 11. Spotify and CD audio comparison of Cem Karaca's Album, Cemaz ül Evvel.

Figure 12 shows that Tarkan's album "Aacayipsin", one of the best-selling albums of its time, was uploaded in low quality.



Spotify *Original CD*

Figure 12. Spotify and CD audio comparison of Tarkan's Album, Aacayipsin.

The Spotify listening rates for artists listed in Table 2 all exceed one million streams per month. A comparative analysis was conducted between the original CDs of selected albums from each artist and the corresponding tracks available on Spotify and Apple Music. This analysis revealed that all of the albums were uploaded in different audio qualities way lower than the promised quality of these streaming services. In conclusion, none of the albums met the expected audio quality standards.

ARTIST	ALBUM NAME	YEAR	MONTHLY LISTENERS ON SPOTIFY
SEZEN AKSU	Firuze	1982	5.600.000
TARKAN	Aacaipsin	1995	3.900.000
İBRAHİM TATLISES	Klasikleri	1995	2.900.000
AJDA PEKKAN	'93	1993	2.400.000
AHMET KAYA	Dokunma Yanarsın	1992	2.350.000
ŞEBNEM FERAH	Od	2013	2.000.000
CEM KARACA	Cemaz-Ül-Evvel	1994	1.900.000
NAZAN ÖNCEL	Ben böyle aşk görmedim	1994	1.600.000
NEŞET ERTAŞ	Gönül Dağı	1999	1.200.000
LEVENT YÜKSEL	Medcezir	1993	1.150.000
FİKRET KIZILOK	Zaman zaman	1983	690.000
AŞIK VEYSEL	Klasikler	2016	275.000
BÜLENT ORTAÇGİL	Oyuna Devam	1991	235.000

Table 2. Examples of low-quality uploaded albums sorted by monthly streams (Spotify, 2024)

An important fraction of the study is shown in Figure 13. A total of nearly 300 songs from 15 artists given in Figure 13 were examined and approximately 200 low-quality samples were identified. It was observed that many of these songs did not meet the promised 256 Kbps resolution but were uploaded at slightly lower resolutions.

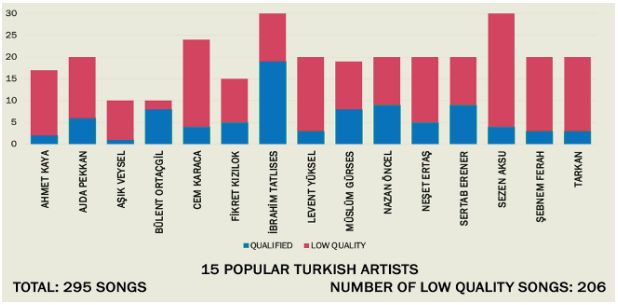


Figure 13. Investigation results of various songs of 15 popular Turkish artists

Although the results reject the H1 and H2 hypotheses, a supplementary study was conducted to further corroborate the findings.

Study 5: Testing whether audio files with lower than promised audio quality can be uploaded to music streaming platforms or not.

The objective of this study is to investigate whether music streaming platforms implement audio quality control procedures for uploaded audio files and whether low-quality music works can be uploaded to the platform. In this study, three musical compositions originally recorded in 24bit/44.1kHz resolution were converted to compressed formats with a 128 Kbps bit rate, resulting in irreversible quality loss. Subsequently, these formats were upscaled to 24bit/44.1kHz resolution and increased to 160Kbps. Despite the resolution being upscaled, the perceived sound quality remained at 128Kbps due to the irreversible quality loss incurred in the initial conversion. The purpose of this experiment is to determine whether music platforms perform frequency analysis in addition to file resolution checks during uploads, which is to say, whether they assess the perceived sound quality alongside file quality specifications.

Some of the songs in the three separate music albums were converted from their original versions with 24bit 44.1kHz to 128 Kbps and 160 Kbps sound quality, and were converted back to 24bit 44.1kHz format and distributed to the world music network through 3 separate digital distributors that can be accessed from Turkey (The Orchard – Entertainment Factory – Distrokid), also transferred from the digital network to Apple Music and Spotify.

It was found out that all of these digital distributors allow low quality uploads. It has also been observed that Distrokid allows compressed file (mp3) uploading (Figure

13) with a notification, while The Orchard and Entertainment Factory's audio upload platforms do not support compressed formats. All these findings reject the H1 and H2 hypotheses.

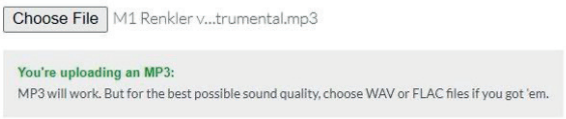


Figure 14. The notification "you are uploading an MP3" on Distrokid uploading platform. (Dsitro Kid, 2023)

Conclusion

Audio streaming platforms have replaced the physical sales operations of record companies over the years and have become a major part of consumers' music needs. Since audio quality is a crucial aspect of the digital experience these platforms offer, it becomes a key element of their marketing messages. In essence, high-quality audio becomes a selling point, similar to a physical product.

In the study, it was seen that the promise of "high audio quality" of the platforms is not met in a consistent manner.

Initially, the platforms verify the compression format of the uploaded tracks, but they do not employ spectrum analysis for this purpose. Consequently, a song with low bit rate and limited frequency response could be uploaded and appear as a high-quality file, bypassing the platform's checks. This control deficiency represents a significant loophole, potentially allowing any uploaded track to suffer from inferior sound quality.

Additionally, concerning Turkey, it was noted that during the initial stages of the sector's digitization process, a large-scale catalog transfer occurred, leading to the upload of music pieces with notably low sound quality to the platforms. It is conceivable that similar transfers might have happened not only in Turkey but also in other countries globally. As a result, a considerable portion of musical works produced before the 2000s might possess substandard audio quality. This situation may prompt platforms to reevaluate how they communicate their value proposition to users.

Considering these facts, it can be confidently asserted that music streaming platforms do not consistently deliver the audio quality promised for all content. Moreover, music streaming platforms do not conduct adequate audio quality checks on all uploaded songs in accordance with the quality standards they have promised.

Despite these discrepancies, consumers continue to subscribe to premium services, leaving the impact of audio quality on subscription rates an open question. While past research suggests some audio quality differences are inaudible to listeners, our study identified issues even amateur listeners could detect in streaming platform

catalogs. This underscores the need to understand how much consumers value audio quality and whether it should be included as a factor in technical service quality.

However, our study does have certain limitations. The analysis was conducted on 500 selected Turkish musical pieces uploaded to digital platforms in the early 2000s. It remains uncertain how many of the identified inconsistencies reflect the entirety of the platforms' catalogs. Therefore, it is challenging to definitively determine the extent of consumers' indifference towards audio quality. Nevertheless, as highlighted earlier, the absence of audio quality controls during the uploading of new tracks emphasizes that this matter should not be overlooked. Further investigations would contribute both to consumer behavior literature and the music industry.

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